BULLETIN 258] [JANUARY, 1918

Ontario Department of Agriculture

ONTARIO AGRICULTURAL COLLEGE

The More Important Fungus and Bacterial Diseases of Vegetables in Ontario.

By J. E. Howitt and D. H. Jones.

INTRODUCTION.

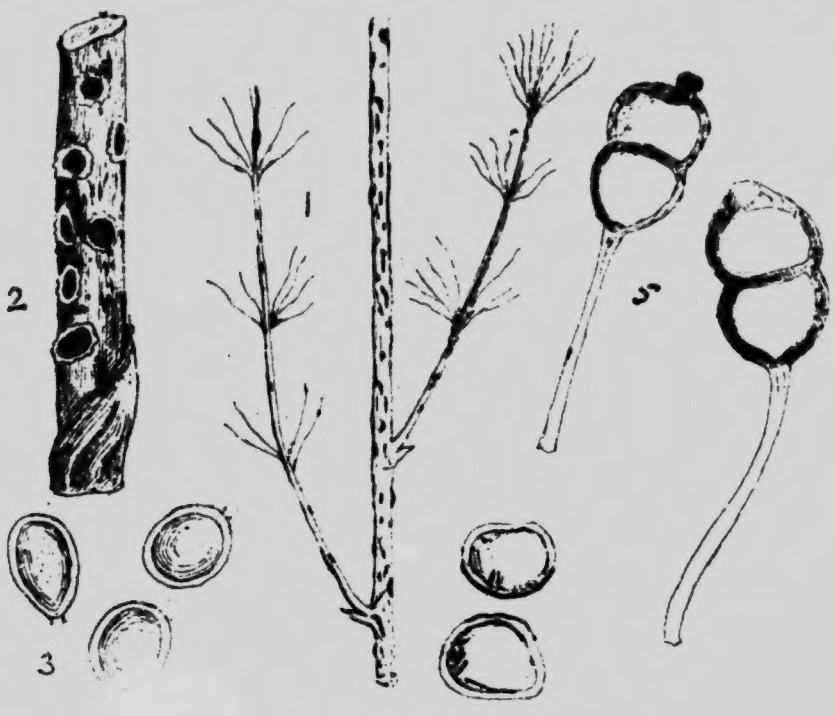
The object of this bulletin is to furnish all who are interested in the growing of vegetables with information which will enable them to identify the more common fungus and bacterial diseases of vegetables and to apply intelligently the treatments which experience has proved to be the most effective in each case.

In a bulletin of this nature it has been thought wise to include the bacterial with the fungus diseases, in order to place in the hands of the grower a complete and convenient manual of all the more important diseases of vegetables.

The majority of the diseases of vegetables are what are known as fungus diseases. It is important that those having to deal with them should understand fully the cause of such diseases, in order that they may apply intelligently remedies for their control. Fungus diseases are caused by plants known as fungi. These plants, unlike ordinary flowering plants, have no green coloring matter (chlorophyll) and are unable, therefore, to manufacture their own food. All their nourishment must be obtained from decaying animal or vegetable remains or from living plants or animals. Those fungi which derive their nourishment from living plants in so doing injure them in various ways, and thus give rise to what are known as fungus diseases.

The bodies of fungi which cause plant diseases are usually extremely small and very simple, consisting of very fine, delicate, thread-like structures (hyphæ), some of which become modified and produce reproductive bodies called spores, which may be considered similar to the seeds of flowering plants. Sometimes the fungus threads live upon the surface of the plants and obtain their nourishment by sending down little suckers (haustoria) into the cells below. Most frequently, however, they live within the plants, either in or between the cells. Two kinds of spores are usually produced—thin-walled summer spores, which spread the disease during the growing season, and thick-walled resting or winter spores, which serve to carry the disease over the winter. Spores are scattered by various agencies, chief among which are wind, water and insects. On coming in contact with a suitable host plant, they send out little threads (germ tubes), which enter the plants through the breathing pores on the leaves (stomata), through the skin or through wounds. Once within the plant, these little threads grow rapidly, drawing their nourishment from the cells of the host plant and setting up a diseased condition.

Generally speaking, in combating fungus diseases methods of prevention only are practicable, as once a fungus is within the plant nothing can be done to destroy it. Care should be taken to keep the crops in a healthy growing condition and free from injury by insects. Unthrifty plants and those attacked by insects are more liable to fungus diseases than healthy ones. Rotation of crops should be practised, so that the winter spores left in the soil may not infect the next season's crop. Weeds should be destroyed, as they frequently harbor fungi. Diseased crop refuse should be burned and not thrown on the manure heap. Fresh manure should be avoided, as it frequently contains living spores of parasitic fungi.



Asparagus Rust.

1. Attac[illegible]em showing spore clusters.
2. Cluster-cup form.
3. Spores from cluster-cup.
4. Spores from summer stage (uredospores).
5. Resting or winter spores (teleutospores).

Intelligent and thorough spraying with Bordeaux or other fungicides will do much to prevent the spread of fungus diseases. It should be kept in mind, however, that spraying is done not to cure, but to prevent disease. In other words, the object of spraying is to cover the surface of the leaves, fruits or other parts of the plant with a substance poisonous to the spores of fungi, in which they cannot grow and penetrate the plant. Spraying, therefore, in order to be effective, must be timely and thorough. The spray mixture must be on the plant before the spores reach it, and the surface of the leaves, fruit and other parts of the plant must be covered so completely that there is not the smallest space on which a spore can germinate.

ASPARAGUS.

Rust (*Puccinia asparagi*, DeC): This disease is very common in Ontario, and is familiar to nearly every grower of asparagus. Sometimes it is reported as causing serious injury to asparagus plants.

The disease has three distinct stages. The first is known as the "cluster-cup" stage or the spring form. In this stage the spores are produced in cup-shaped pustules, which are grouped in oval clusters and are orange-yellow when mature. This form is seldom noticed by the growers. The second or summer stage is the one that is usually first noticed and called by them the Red Rust, on account of the elongated reddish-brown pustules which are seen breaking through the skin on the stem. In these pustules reddish, one-celled spores are produced, known as uredospores. It is in the summer or red rust stage that the disease spreads most rapidly and appears to do the greatest amount of harm. Towards fall, or whenever the vitality of the asparagus plants is reduced, the third and final stage known as the black rust or winter rust appears, owing to the fact that the red spores in the pustules are replaced by dark brown, two-celled, thick-walled spores, known as teleutospores. These germinate in the spring and give rise to the first stage again. The rust organism is, therefore, carried over the winter chiefly as spores on the old stems of the asparagus plants.

Prevention. Let no plants, not even wild ones, mature during the cutting season. Late in the fall, when growth is nearly over, cut out and burn the old plants. Plant Rust-resistant varieties. The Palmetto variety is said to be more resistant than many of the other common varieties. Spraying with Resin Bordeaux from July to September at intervals of ten days to two weeks, is recommended by some American investigators. This, however, is a difficult and costly undertaking, and it is doubtful whether it will pay here in Ontario.

BEANS.

Anthracnose or Pod Spot (*Colletotrichum lindemuthianum*, (Sacc. & Magn.) Bri. & Cav.): The commonest and most serious disease to which beans are liable. In wet seasons it causes great loss, particularly in the bean-growing sections of Kent County.

Pods, seeds, leaves and stems are affected. On the pods sunken, reddish-brown or black spots, usually with rusty brown borders, are seen. In the centre of these spots pinkish masses may be noticed frequently. Affected seeds show dark brown or rusty discolored spots. These are often very minute. On the leaves the chief symptom is the brown and rusted appearance of the main veins underneath. Sometimes these appear as if cut or eaten out by the fungus. Occasionally small holes appear in the leaf, due to the destruction of the veins by the fungus. On the stems, rusty brown, elongated spots are sometimes seen. Occasionally these spots are so deep as to cause the stem of the leaf to break at this point.

The fungus which causes this disease is carried over the winter as dormant fungus threads (mycelium) in the seed. In the spring the disease first appears on the seed leaves (cotyledons) of the young plants. On these the first crop of spores of the season is soon produced. During wet weather the disease spreads very rapidly. The pods are attacked and the fungus penetrates through the tissue of the pod into the seeds. Here it remains in a more or less inactive condition until the seed is sown.

Prevention. Since the disease originates with infected seed, the most important point is to secure, if possible, clean seed. How are we going to obtain such seed? Seeds that are badly infected may be readily recognized by the discolored spots. Hand-sorting of the seed previous to sowing should help to reduce the amount of Anthracnose, but as a certain percentage of apparently healthy ones may contain the fungus the only sure way of obtaining non-infected seed is by gathering it from pods which are free from spots, the fungus, so far as is known, only infecting the seed through the pod. Hand-sorting of disease-free pods may not be practicable for large areas, but is quite practicable for small garden plots and for seed plots from which to obtain seed for the general crop where a large acreage of beans is grown. The seed plot should be watched closely and any diseased plants removed.

If possible a rotation of crops should be practised, beans not being sown on the same land more than once in three or four years. Bean straw should not be used for manure in fields where beans are to be grown. If the disease is present in the field, care should be taken not to work among the plants when they are wet with rain,

Bean Anthracnose Pods, showing the spots characteristic of the disease. (Original.)

since it is at this time that the spores are ready to be distributed, and each spore may start a new spot.

Spraying with Bordeaux mixture does not appear to be effective in controlling this disease. Treating the seed with formalin or other chemicals has not yet proved a practical success for the prevention of this trouble.

Rust (*Uromyces appendiculatus* (Pers.) Lev.): This disease is occasionally seen in Ontario, but seems to be of very little economic importance. It appears as small, round, rusty-brown, raised spots, chiefly on the under surface of the leaves, though leaf-stalks and pods may also be affected.

Prevention. It seldom calls for any particular treatment in Ontario, but if it should become serious it would be advisable to spray with Bordeaux mixture and burn the remains of diseased plants.

Bean Blight—Bacteriosis of Beans. Causal organism, *Ps. phaseoli* (Smith): Whilst there has been no record of heavy losses from this disease in Ontario, we get every year bean plants suffering from the disease forwarded to us. Letters accompanying these plants often state that considerable damage was done to the fields from which the plants were taken, many plants being attacked in the same way. Scarcely a season passes but what more or less of this disease is present in

the beans of the College garden and in the bean plots in the experimental grounds. In the United States where wax beans and lima beans are grown extensively, heavy losses are caused by the disease, and it is getting more general in Ontario.

Beach of the Geneva Station established the bacterial character of the disease on lima and wax beans in 1892, and Halstead of the New Jersey Station in the same year arrived at similar conclusions after making a series of experiments. Erwin Smith in 1897 first described the causal organism, *Ps. phaseoli.* Work dealing with this disease has also been done in this laboratory.

Appearance of the Disease. The disease may be found on the foliage, the stems, the pods and the beans within the pods. At first the disease on the pods appears as small, water-soaked areas. These areas gradually enlarge and usually are outlined by a reddish-brown border. As the disease progresses and the areas continue to enlarge, the whole of the affected area becomes a light brown, and does not develop the black or pink color or the sunken spots produced by anthracnose. The foliage becomes spotted and yellowed in large areas of the leaf surface, soon withers and falls away.

Method of Infection.

Leaves. The disease usually begins at the margin of the leaf, or where the leaf has been torn by insects, wind or hail. Here the germs find entrance into the tissues through the wound. A yellow spot is formed and the green color destroyed. The spot increases in size rather slowly, and the diseased tissue becomes brown and papery, turning dry and brittle in the sun and soft in the rain, and then is often torn away, leaving ragged margins and holes in the leaf. The whole leaf may die and fall to the ground or remain withered on the stem.

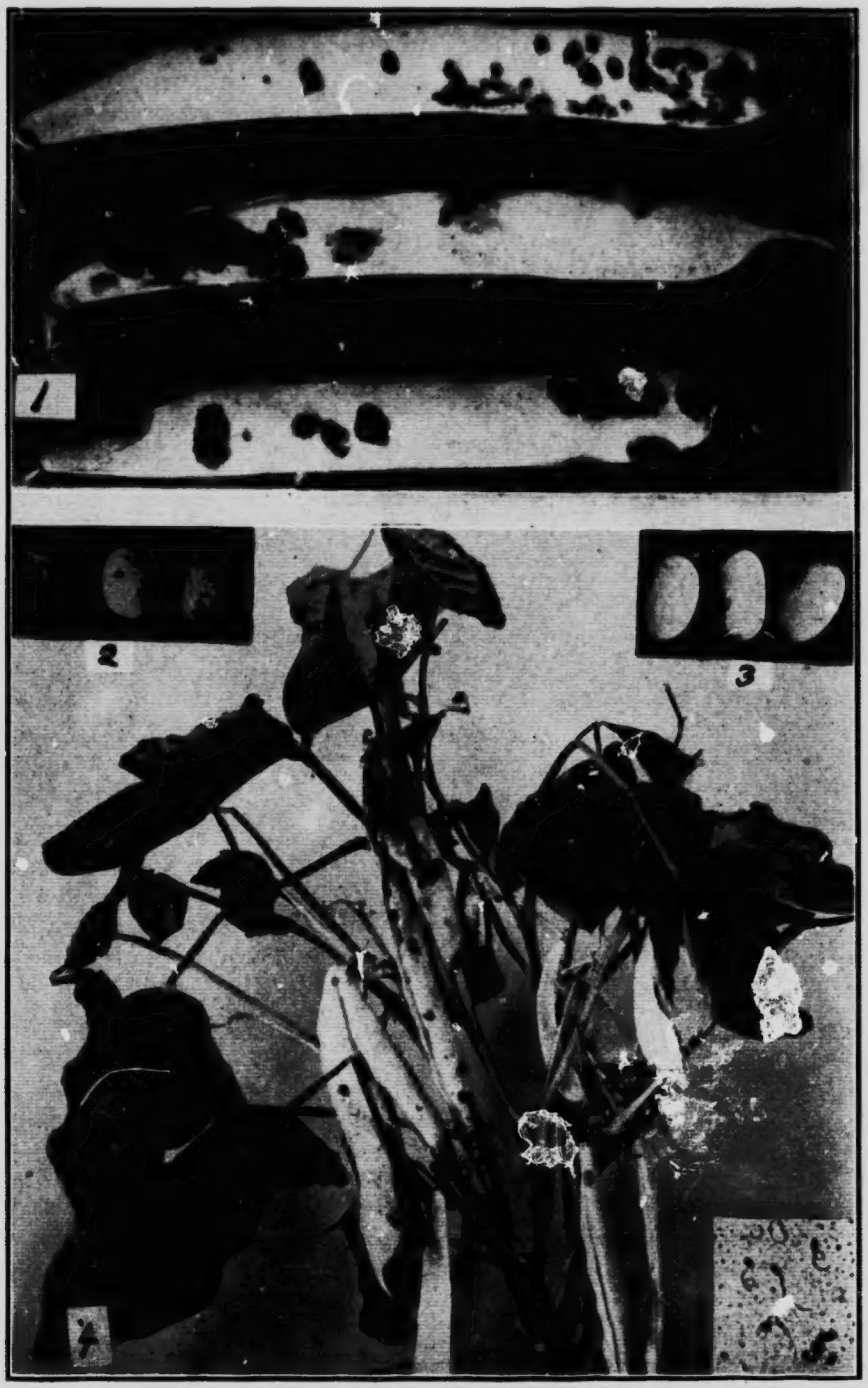
Stems and Pods. The disease usually enters the stem by way of the leaf stalk, and advances in the stem to other leaves and to young pods. In severe cases the pod may wilt and die, and on opening it the half-grown seeds will be found shrivelled and discolored by irregular, brownish areas outlined by the characteristic reddish-brown margin. The beans may be apparently sound or only slightly discolored or they may be much discolored. The whole plant does not usually die outright, but lingers through the season. Separate infections may occur at any place on pod or stem.

Seed Beans. In germination tests of diseased beans less than half the number sown germinated. The remainder rotted. Those that germinated never produced healthy plants, but plants that were weak and soon wilted. Healthy seed sown under the same conditions germinated ninety-eight per cent., and produced vigorous, healthy plants.

The germs live over winter in the tissue and infect the plant on germination.

In appearance the disease is somewhat similar to Bean Anthracnose or "pod spot" caused by the fungus Colletotrichum lindemuthianum, but this latter may be distinguished by its making rather deep pits in the affected areas, which are pinkish and produce spore-bearing pimples.

In morphology and cultural characteristics *Ps. phaseoli* is practically identical with *Ps. campestris,* which causes wilt or black rot of cabbages. But while it is pathogenic for beans, peas and lupines, it is not pathogenic for cabbage or cauli-



Bacteriosis of Beans. (Original).

1. Diseased pods.
2. Diseased beans from diseased pods.
3. Healthy beans.
4. Bean plant badly affected with bacteriosis in foliage and pods.
5. *Ps. phaseoli*, the cause of the disease.

flower. And while *Ps. campestris* is pathogenic for most cruciferæ, it is not pathogenic for the leguminosæ.

The organism has been isolated by Delacroix from French grown plants at Paris.

Eradication and Control.

1. Do not sow seed from diseased plants. Affected seed will usually be more or less shrunken or shrivelled or have a varnish-like shiny yellowish or amber-colored appearance. This varnish-like coating of the seed is due to an exudate from the diseased pod in which the seed has been produced, and it contains thousands of the bacteria, many of which live over until the next season, ready to develop after the seed is sown, when they will attack the young seedling.

2. Carefully look over the crop when growing and remove and burn any plants showing indications of the disease. If affected plants are allowed to remain growing in the crop, the disease will be spread from them to the surrounding healthy plants by insects, and during cultivation or other handling.

3. Do not throw straw from diseased crop on to the manure pile, but carefully rake up and burn.

BEET.

Leaf Spot (*Cercospora beticola*, Sacc.): This disease is very common in Ontario, but seldom causes serious injury to garden varieties. The leaves of Sugar Beets, however, are sometimes destroyed by it. It is easily recognized by the small white or brown spots with purplish margins, which are scattered irregularly over the leaves. In the later stages these spots become ashy-grey in color. When they are very numerous the leaf tissue is, to a large extent, destroyed, and the value of the leaf to the plant correspondingly lessened.

Prevention. This disease is seldom bad enough to require treatment. Spraying with resin Bordeaux at intervals of ten to fourteen days, beginning about the middle of July, is recommended.

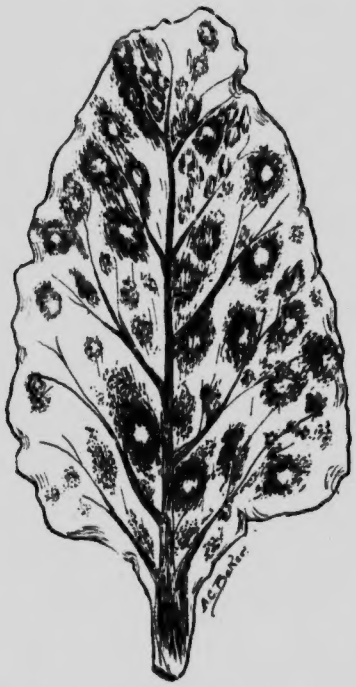
CABBAGE AND CAULIFLOWER.

Club Root (*Plasmodiophora brassicæ*, Wor.): This disease attacks cabbage, cauliflower, turnips, radishes and other members of the Mustard family (*Cruciferæ*). It is a very troublesome disease in the Maritime Provinces and has been found in Ontario, but does not appear to be established in this province.

It is caused by a slime fungus. Affected plants are noticed to flag or wilt markedly, and if their roots are examined, irregular thickenings and knob-like swellings are found upon them. These often reach the size of a man's fist. The tops of diseased plants develop very slowly, cauliflower and cabbage attacked forming little or no head. The plants are often completely killed, since the swellings on the root prevent the proper absorption of water. The cells of the swellings when examined under a microscope are found to be large and filled with irregular brownish masses of protoplasm. Each such mass represents the vegetative body

of a single organism. These vegetative bodies feed and grow at the expense of the cell contents, and when the food supply is exhausted each one divides into a large number of spores which, when the diseased roots decay, are set free into the soil in thousands. Naked, motile pieces of protoplasm emerge from the spores when they germinate. These enter the plant through the root hairs. The organism may remain in the soil for several years. It is chiefly spread in manure, by means of infected seedling stock, and possibly by spores adhering to the seed.

Prevention. Great care should be taken to prevent this disease being introduced and established in this province. Seed, if possible, should be obtained from a locality where the disease does not occur. If the seed has been obtained from an unknown source, as a precaution it is advisable to disinfect by soaking it for fifteen minutes in a solution of corrosive sublimate, of the strength of one part by



Leaf of beet attacked by leaf-spot fungus (*Cercospora beticola*).

weight to 1,000 of water. Tablets can be purchased, of which one tablet to a pint of water gives a solution of the required strength. Notice well that corrosive sublimate is a deadly poison, and should be kept away from children and stock. It also corrodes metal, and therefore should be mixed in wooden pails. Care should also be taken not to plant seedlings showing any signs of the disease.

If a few plants in the field develop the disease, dig them up, taking care to get all the root, and burn them. If the disease becomes established in a field a four or five-year rotation of crops should be practised, so as to avoid growing turnips or cabbages on the same soil for a number of years. Applications of lime every few years are of great value in lessening the severity of the attacks. Two to three tons per acre of air-slaked lime should be applied, preferably three or four years before sowing or planting a cruciferous crop. Lime the seed bed for cabbage and

cauliflower in the same manner. Burn all refuse from diseased crop. If it is necessary to feed diseased turnips or other roots they should be thoroughly boiled before feeding. Do not use manure containing cabbage or cauliflower refuse, and if possible keep down weeds belonging to the Mustard family (*Cruciferæ*). These may harbor the disease.

Bacterial Wilt of Cruciferæ (Black Rot of Cabbage, Turnip, Rutabaga, etc.). Causal organism.—*Ps. campestris* (Pammel). This wilt, commonly known as Black Rot of Cabbage and sometimes as Brown Rot, is a very bad disease, and causes much loss to the kitchen gardener. It is found attacking many cruciferous plants, including cabbage, cauliflower, collards, Kohl rabi, kale, Brussels sprouts, broccoli, rutabagas, turnips, wild radish and mustard, the latter, unfortunately, only to a very slight extent.

Club Root of Cabbage. (Original.)

It is widely distributed, occurring throughout Canada, the United States, Great Britain, Holland, Germany, Denmark, Austria, France, Switzerland and other countries.

The specific cause of the disease was first ascertained by Pammel of Ames College, Iowa, in 1895, when, on investigating a bad outbreak of a black rot of rutabagas he isolated a germ which he named B. campestris, grew it on various culture media, and, by inoculating healthy plants with the cultures so obtained, produced in them the disease and from these plants reisolated the germ. Bulletin 27, Iowa College Experiment Station, 1895).

Erwin Smith, in 1896 (see Centralblatt für Bakteriologie, II Abte., Vol. 3, 1897), on investigating a brown rot of turnips and a black rot of cabbages, infected material of which was forwarded to his laboratory, isolated a germ which proved

to be identical with that isolated by Pammel the year before from rutabagas. He conducted numerous inoculation experiments and established the germ as being the specific cause of the wilt of many cruciferous plants which is so common in moist weather, and which causes heavy losses to market gardeners.

Appearance of the Disease. In the growing cabbage plant the disease manifests itself as a yellowing or browning of the leaves. This yellowing occurs in irregular areas sharply defined, which gradually enlarge until the whole leaf becomes browned, wilted and shrivelled.

If the plant be attacked by the disease when young, it will not develop normally, but will be dwarfed, and will present a pale, sickly appearance, and often no head will be produced in the case of a cabbage, and no bottom produced in the case of a turnip or rutabaga. (See illustration.)

The browning and wilting of the leaves is due to the supply of sap being cut off in the veins and midribs that are situated near or within the brown areas.

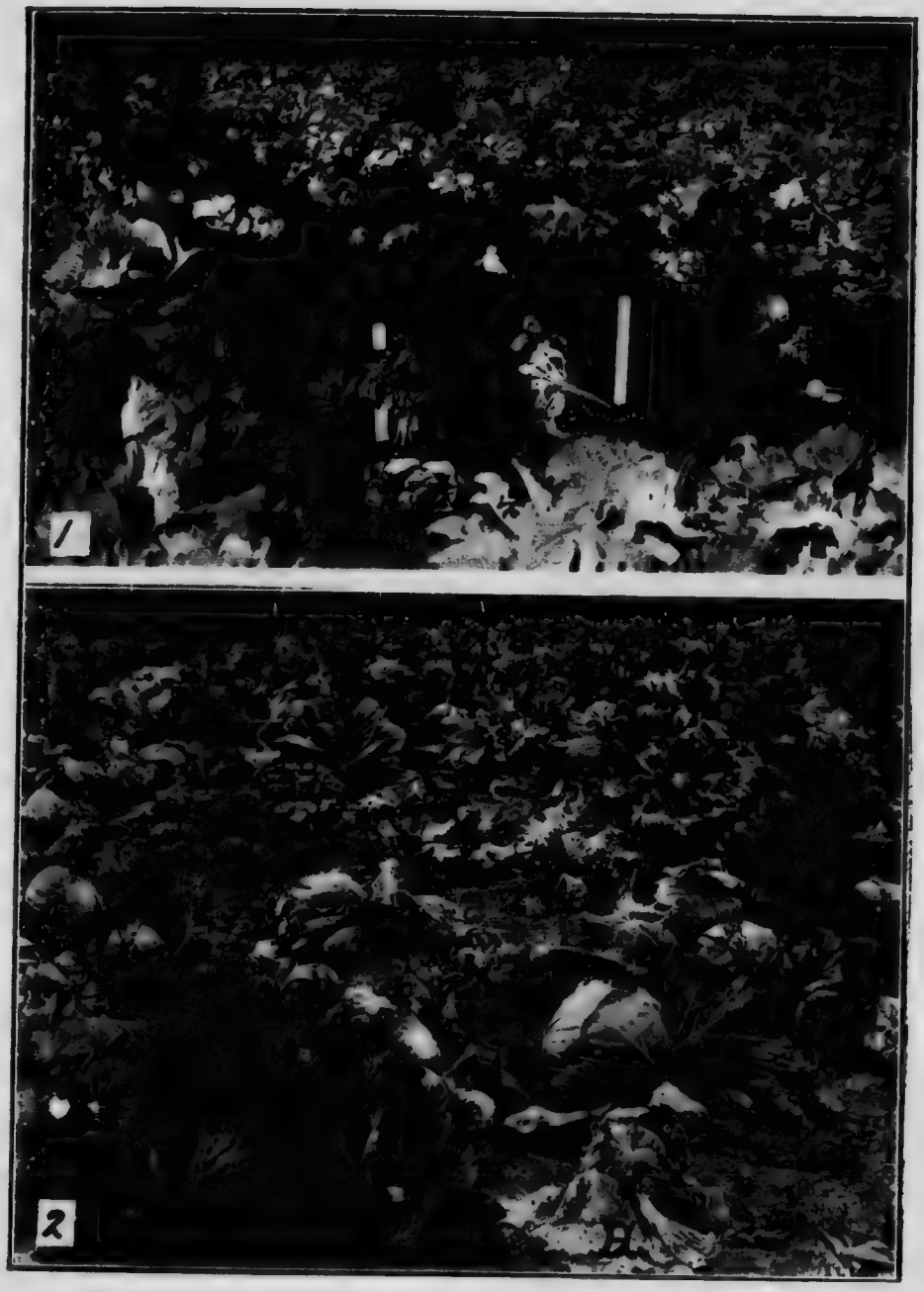
If the midrib of a diseased leaf or the veins leading from a diseased part of a leaf be cut it will be noticed that the vascular bundles or fibres are black or dark brown instead of yellow or white. This discoloration is due to the presence and action of immense numbers of the disease-producing bacteria within the veins or fibro-vascular bundles. Here they feed on the sap, multiply rapidly and choke up the passages so that the supply of sap is cut off from the surrounding tissue, thus causing it to yellow, wilt and die.

If the whole head of cabbage be yellowish, sickly and wilted, or if several leaves of a cabbage present such an appearance, a section of the stalk, either cross or longitudinal, will almost invariably reveal the disease in the blackened vascular bundles forming the vascular ring, the woody portion of the stem. In such a case the germs will have spread almost throughout the entire vascular system of the plant, passing down the veins of the stem to veins of other leaves until the whole plant became affected and worthless. (See illustration.)

Means of Infection.—Infection is most common at the water pores around the margin of the leaf. In the early morning, especially in moist weather, dewdrop-like beads of water may be noticed around the leaf margins of growing cabbages. This is usually water of exudation given off by the plant through the water pores. If the atmosphere were dry this water would not be found there, as it would evaporate as soon as it came to the surface of the plant. But when the atmosphere is moist this evaporation does not take place, and so the water extruded from the pores forms little beads.

Should the disease germs by any chance get into these drops of water it is very easy for them to enter the vascular system of the plant through the open pores. Thousands of cases where such has been the means of entrance of the germs into a plant have been observed.

The question remains: How do the germs get into the drop of water? This may occur in several ways. Slugs and caterpillars crawling around after feeding on or crawling over a diseased plant may carry and deposit the germs wherever they crawl on the healthy plants. The cultivator, in passing along the rows, may brush against and wound a diseased plant, and some of the germs thus get on to the cultivator, and so be carried along and brushed off on healthy plants. In transplanting the hands of the workman may become contaminated from handling a diseased plant, and plants subsequently handled have the germs deposited on them from the hands of the workman. Even should the plant be dry at the time it is so contaminated, the germs may remain alive on the plant for days until the right conditions



Bacterial Wilt of Crucifereae (Black Rot of Cabbage). (Original).

1 and 2. Views in a cabbage plantation, showing numerous cases of the disease in all stages of development.

occur, that is, sufficient moisture be present in the atmosphere and in the soil to allow of the formation of water drops at the water pores when infection would take place.

Again, biting insects, caterpillars, slugs, and other forms of animal life which feed on growing cabbages, may, after feeding on a diseased plant, inoculate directly a healthy plant by biting through one of the small leaf veins and depositing there some of the germs adhering to their mouth parts after their visit to the diseased plant. Such means of inoculation have been observed again and again. Caterpillars and slugs feeding on diseased leaves have been transferred by hand to healthy plants, and in a large percentage of cases the disease has subsequently developed in the healthy plants at the point where the caterpillar was placed.

Infection through contaminated seed may occurr. By a series of experiments conducted at the New York Experiment Station, Geneva, it has been proven that the germ can live on dry seed for longer than nine months. Such contaminated seed, when germinating, is liable to infect the young plant, and cases of such infection may occur in seed beds.

Again, seed beds are often badly contaminated with the germ by spreading on them material from the manure pile or compost heap where diseased plants have been deposited to rot. And while it is very doubtful that the germ enters the plant through the root hairs, any injury to the root, or leaves that are near the ground, may result in the inoculation of the plant with the disease. Caterpillars and slugs crawling over such soil would be very liable to inoculate the plants growing there by crawling over and feeding on them.

Control of the Disease. The best way to keep the disease under control is to prevent its development.

Disinfecting the seed. It was proven at the Geneva Station that germs on the seed may be killed without any injury to the seed by soaking it for fifteen minutes either in a corrosive sublimate solution or in formalin.

If corrosive sublimate is used, the strength of the solution should be one part corrosive sublimate to one thousand parts of water. The most convenient method of preparing this solution is to use the corrosive sublimate tablets sold by druggists for making disinfecting solutions. One tablet, costing one cent, is sufficient to make a pint of solution, which is about the quantity required to treat one pound of seed. The seed should be soaked in this solution fifteen minutes and then spread out to dry.

If formalin is used the strength of the solution should be one part formalin (40 per cent. formaldehyde) to 240 parts of water and the seed soaked for fifteen minutes.

A convenient method of treating the seed is to place it in a small bag made of any loose cloth readily penetrated by water and suspend the bag in the disinfecting solution for the required length of time. The seed should be dried without delay in the shade.

Handling Diseased Plants. Should the disease be noticed among seedlings in the seed bed, the diseased plants should be removed and burned. If they are not burned the germs within them are liable in many ways to get transferred to the healthy stock, and so the disease be spread instead of being checked.

Seedlings that show signs of the disease should not be planted out. It is not usually of much service simply to break a diseased leaf from what appears to be an otherwise healthy plant. If the disease is confined to the marginal areas of the leaf entire then breaking off the leaf would prevent the rest of the plant from

Bacterial Wilt of Cruciferae (Black Rot of Cabbage). (Original).

1. Cabbage leaves affected with the bacterial wilt or black rot. The lighter-shaded areas around the outer edge of the leaves are the diseased parts showing natural inoculation through the water pores on the edge of the leaves; the light-shaded areas were yellow.
2. The lighter shade part of the leaf near the base indicates the diseases, and the blackened vascular bundles of the stem, where it is cut, indicates that the disease entered this leaf from the main stalk of the cabbage.
3. Cabbage stalk and stunted head; the blackened vascular bundles indicate that the disease was general throughout the plant. The leaf [illegible] was taken from this plant.

developing the disease. But should the vascular bundles in the midrib of the leaf at the point of its contact with the plant stalk be discolored brown or black, we may take it for granted that the germs are already established in the vascular bundles of the stalk. So, after breaking off a diseased leaf, one should look to see if any discoloration of the vascular bundles exists, and should there be any, the whole plant should be destroyed.

If an entire bed, or a considerable portion of a bed be badly attacked, all the plants should be pulled and burnt and the broken leaves, etc., raked up and burnt also. Cabbage or turnips should not be planted again on such ground for one or two years.

Insects and caterpillars, slugs, etc., should be kept in check, as they are noted carriers of the disease germ by feeding on diseased plants and then going to healthy plants.

CELERY.

Late Blight or Septoria Leaf-spot (*Septoria petroselini*, Desm. var. apii, Br. & Cov.): The common and destructive celery blight in Ontario. In wet seasons it is very injurious and ruins large quantities of celery. It is not usually noticed by the grower until late in the season, but a careful observer usually can find a little of it in the field shortly after the plants are set out.

On infected leaves irregular brownish spots usually develop. In these may be seen numerous minute black specks—the fruiting bodies of the fungus (pycnidia). The spots may be numerous and close together, and the leaf may wither and die. When the disease is bad, however, on many of the leaves the characteristic spots may not develop, but the whole leaf may be affected at once, become covered with minute black specks, dry and wither up. The lower leaves are nearly always the first to show the symptoms of the disease. The stems also are affected. On these irregular, rusty-brown, somewhat water-soaked areas with the characteristic minute black specks are seen. The disease develops further after the plants are lifted, and may subsequently cause serious rotting in storage.

The fungus which causes this disease is carried over the winter by spores in the diseased leaves, both in soil and manure. Infected seed is thought to be another means by which the fungus may winter over. In our experiments to determine this point, we have failed to secure any conclusive evidence that infected seed produces blighted plants. Our experiments, however, are still in progress, and it is yet too early to come to any definite conclusions from them.

Prevention. Spray with Bordeaux mixture (4.4.40 formula), commencing when the plants are in the seed bed and repeat at intervals of ten days or two weeks. The spraying should be continued as late as possible, leaving only a sufficient interval for the stain of the Bordeaux mixture to disappear before harvesting the celery. When the plants are large it is necessary to apply the spray with a good pressure in order to insure covering every portion of them. To do thorough work it is often advisable to go over every row twice at each spraying. Only thorough spraying pays. Our experiments in spraying to control Late Blight of celery have been carried on for four successive years, and the results show conclusively that loss from this disease can be prevented by spraying as recommended above. Experiments conducted under the direction of S. C. Johnston, Vegetable Specialist for the Ontario Department of Agriculture, have proved that such spraying is a commercial success. It is now practised by many of the large celery growers in Ontario.

It is not advisable to attempt to store for any length of time celery affected

with Late Blight; before such celery is placed in storage the blighted leaves should be stripped off. Diseased celery tops should not be left lying on the ground or thrown on the manure heap, but should be raked up and burned.

EARLY BLIGHT or CERCOSPORA LEAF-BLIGHT (*Cercospora apii*, Fr.): This disease appears to be of little importance in Ontario. It is seen to some extent nearly every year, but the writer has never observed it causing serious injury. Affected leaves are characterized by more or less circular spots, greyish-green in color at first, then becoming brown and later ashy. Separate spots generally have a well marked border. When numerous they run together in irregular patches.

Prevention. Spraying and cultural methods as recommended for Late Blight will also prevent this disease.

Late Blight of Celery. (Original.)

CORN.

CORN SMUT (*Ustilago zeæ* (Beckm.) Ung.): This smut is exceedingly common and familiar to nearly everyone who grows any corn. The sugar or table corns seem to be more subject to smut than the field corns, but no varieties are entirely free. Corn Smut attacks the ears, stalks, leaves and tassels. It produces on the parts affected peculiar growths, frequently spoken of as "boils." These "boils" are sometimes six inches or more in diameter. They are white and polished in the early stage, but become dark as they mature and finally rupture and expose a brownish-black mass of powder, consisting of millions of spores.

As soon as the "boils" mature and rupture the spores are scattered by the wind and other agencies. In the soil or in manure they germinate and produce great numbers of secondary spores, which may infect any of the tender growing tissues of corn plants. Thus the disease is spread during the growing season. The

organism which causes the disease is carried over the winter as spores in the soil or in manure. The soil and manure may be contaminated in various ways. The spores may be scattered by the wind or the spore masses may be left in the field or thrown on the refuse or manure pile. Smutted corn may be used for fodder, and it is thought that the spores may pass through the alimentary canals of the cattle without being injured, and thus get into the manure pile. It is believed that the spores of Corn Smut not only live through the winter in the manure pile, but that they actually grow and increase in number in the warm fermenting manure. The Smut organism may live for a considerable time in the manure heap before dying out.

Corn Smut on Ear and Tassel. (About one-half natural size).

Prevention. Treating the seed with formalin or bluestone will not prevent Corn Smut, since the organism is carried over the winter as spores in the soil and in manure.

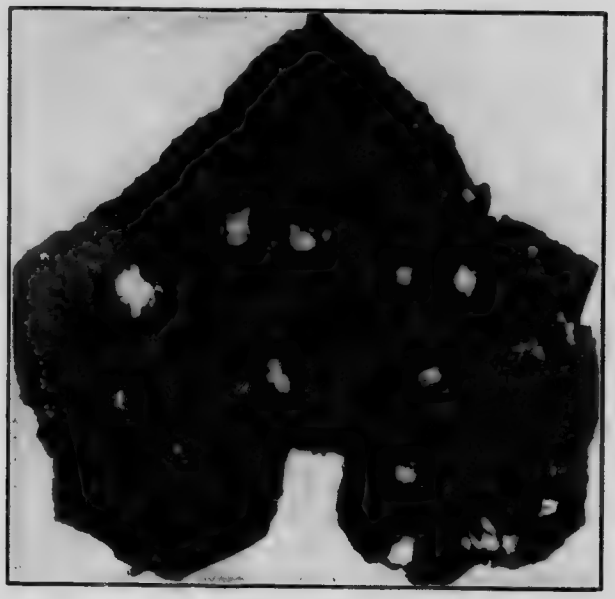
Go through the field and remove and burn all Smut growths as soon as they appear, as each "boil," when it matures, is a source of infection to the healthy plants around it. Avoid fresh manure, as it is very likely to contain live Smut spores. If possible, practise a rotation of crops. Corn Smut spores in the soil will not live for many years, and those which are in the soil cannot injure any other garden crop. After three or four years corn may be planted again with less danger, as many of the spores will have lost their vitality by this time.

RUST (*Puccinia sorghi*): A common but not serious disease. On affected leaves elongated reddish-brown pustules are seen on both surfaces. It is never serious enough to require treatment.

CUCUMBER.

DOWNY MILDEW OR BLIGHT (*Plasmopora cubensis,* (B. & C.) Humphrey): This disease affects cucumber, melon, squash and pumpkin plants, damaging and in bad cases destroying the foliage. It appears as yellow spots, indefinite in outline. If the weather conditions are favorable to the fungus, these rapidly enlarge and finally the entire leaf withers up.

Prevention. Spray early with Bordeaux mixture, beginning when the plants begin to run. If the weather is dry, spraying every ten days will be often enough. If, however, the weather is wet, more frequent spraying will be necessary. For the early application use weak Bordeaux (2 lbs. copper sulphate, 4 lbs. lime and 40 gallons water). Later, when the plants have formed runners the 4.4.40 formula can be used. It is important that both sides of the leaves be covered at each spraying.



Downy Mildew of Muskmelon.
(After F. C. Stewart.)

ANTHRACNOSE OF CUCUMBERS, SQUASH AND WATERMELONS (*Colletotrichum lagenarium,* (Pass.) Ell. & Halsted): A disease frequently seen in Ontario, especially on cucumbers, the foliage of which is often badly damaged by it. On the leaves of affected plants brown, dead, circular spots are seen. These are frequently very numerous, so that the whole leaf is destroyed. On the stems elongated, light brown areas are observed. On affected fruit, especially on the watermelon, water-soaked, sunken spots appear. These often have pink centres.

Prevention. Spray with Bordeaux mixture as recommended for Downy Mildew of Cucumber. Rake up and burn the refuse from a diseased crop. If possible, practise a rotation of crops.

BACTERIAL WILT OF CUCURBITS, Causal Organism, *Bacillus tracheiphilus* (Smith): This wilt often causes serious losses to the growers of cucumbers, squashes,

melons and other cucurbits. Whole plantations of these plants are sometimes completely destroyed, and the disease will pass rapidly through a house of cucumbers.

A diseased plant loses its bright green color and turns to a dull, dirty yellowish green. The leaves and stems become flaccid and droop, hang down limp and lifeless, having lost all turgidity. The fruit, when affected, becomes soft and appears somewhat water-soaked, and if squeezed will readily yield to pressure, and often under such treatment the skin will rupture and a slimy, clear liquid will ooze out. If this liquid be touched with the finger or any instrument, it will be found to be viscid, slimy or gummy, and will string out in long strands. If a diseased stem be broken or cut, similar conditions will be found to exist, i.e., the plant juice will be viscid, slimy, and will string out in long strands when the cut surface is scraped with a knife or rubbed with the finger.

This sliminess or viscidity is the most characteristic feature of the disease, for a plant may wilt for lack of moisture and present an appearance something like a diseased plant. But if such a plant be cut and its juice expressed, this juice will prove to be quite watery and will not draw out in threads.

A microscopic analysis of the slimy juice from a diseased plant will show millions of bacteria within the smallest drop that can be obtained, while a similar preparation made from the juice of a healthy plant or a plant that has wilted merely from the lack of moisture will not show a single germ.

If a little of this slimy juice from a diseased plant be transferred on the point of a needle to the inner tissue of a healthy plant by puncturing the healthy plant with the contaminated needle, in a day or two the plant will wilt, the bacteria inserted on the point of the needle having multiplied so rapidly and spread through the vascular system of the plant.

Pure cultures of the germ on artificial media are rather difficult to obtain, as the germ will not grow readily on the ordinary media. However, pure cultures have been obtained on special media, and these inoculated into healthy plants have rapidly produced the disease.

In the stem and leaf the disease germ is found mostly in the vascular bundles, in the plant juice of which it lives and multiplies, spreading up and down and plugging the sap channels. Eventually the walls of the vascular bundles are broken down and the organism gets into the surrounding tissue to a limited extent.

The flesh of diseased fruit is transparent and water-soaked in appearance.

The plant juice in all affected parts becomes slimy or viscid, and strings out in long strands.

Methods of Spreading.—1. The disease is spread from plant to plant mostly by biting and sucking insects, particularly the Striped Cucumber Beetle and the Squash Bug. These insects, after feeding on a diseased plant, have their mouth parts covered with the germs of the disease, and on subsequently feeding on healthy plants they inoculate the healthy tissue with the disease.

2. The gardener, in removing and destroying the diseased plants, cannot help but get his hands and the tools used badly contaminated with the disease germs, even when exercising the greatest care, and so if he does not take the precaution to disinfect his hands and the tools used before handling any healthy plants, he is very likely to inoculate them with the germs of the disease.

Methods of Control. All diseased plants should be carefully removed and burned immediately. If they are allowed to lie around insects will swarm about

Bacterial Wilt of Cucurbits. (Original).

1. Bacterial wilt of cucumber.
2. Bacterial wilt of cucumber.
3. Bacterial wilt of squash.
4. Stained microscope preparation from the viscous slimy exudate of a vascular bundle of a wilting cucumber plant, showing the bacteria (B. tracheiphilus), (× 1000 di).

them, get themselves contaminated with the germs, and thus spread the disease wherever they go.

Hands and tools used in removing and destroying diseased plants should be thoroughly disinfected by washing them in five per cent. carbolic acid, or in corrosive sublimate of a strength one to one thousand, or some other good disinfectant.

Biting and sucking insects, especially the Striped Cucumber Beetle and Squash Bug, should be kept under control by spraying and hand picking.

LETTUCE.

"Drop" (*Sclerotinia libertina*, Fckl.): This is the most serious disease to which lettuce is liable. It begins with a wilting of the outer leaves, which droop and fall flat on the ground. All the leaves of the plant are soon affected in the same way and in a few days the entire plant is dead and lying flat upon the ground. This sudden and total collapse of the plants has given rise to the name "Drop."

The greatest loss seems to occur when the plants are almost full grown. The fungus appears to spread almost entirely by the mycelium growing through the soil. Dense, compact portions of this mycelium form little masses (sclerotia) by means of which it is enabled to pass over unfavorable conditions intervening between successive crops of lettuce.

Prevention. If the disease becomes bad, sterilize the soil with steam by the inverted pan method, as described on page 47. Covering the surface with sterilized sand or earth has been found to lessen the disease materially, the effect being proportionate to the thickness of the layer added. If these treatments cannot be applied, the only alternative is to change the soil for each crop of lettuce.

Two other fungus diseases, the Downy Mildew (*Bremia lactuca*, Reg.) and Leaf Spot (*Septoria consimilis*) are seen on lettuce to some extent in Ontario, but never seem to be serious enough to require any special attention when the crop is properly managed.

ONION.

Onion Blight or Mildew (*Peronospora schleideniana*, De Bary): This is the commonest disease of the onion in Ontario, and in some parts of the province it frequently decreases very materially the onion crop by destroying the leaves, and thus reducing to a marked extent the size of the bulbs. It usually makes its appearance in late June or July.

Affected leaves first show peculiar violet tinted areas, due to the fuzzy, spore-bearing portions of the fungus on the surface. They very soon become pale or yellowish in spots and collapse and break down. If examined they are seen to be more or less covered with the spore-bearing parts of the fungus, which give to the surface of the leaves a furry appearance. In severe attacks all the leaves in a field or patch are very soon destroyed. They are often, however, quickly replaced by a new crop, which in turn may be destroyed by the disease, and from this second attack the onions do not usually recover.

Two kinds of spores are produced by the fungus, namely, thin-walled summer spores, borne on the minute, branched, spore-bearing parts of the fungus covering the surface of the attacked leaves, and thick-walled resting spores (oospores) formed

in the tissues of the dead leaves. The summer spores are freely scattered by the wind during the summer, and new leaves thus become infected. In this way the disease spreads very rapidly, especially during damp, muggy weather. Dead leaves containing the thick-walled resting spores lie on the ground during the winter, and in the spring the spores germinate and give rise to the disease, if onions are planted again on the same ground.

Prevention. Spraying with resin Bordeaux is recommended by some American authorities for the control of this disease. So far, however, as experiments have been conducted in Ontario, such spraying has not proved satisfactory, but more experiments must be made before we are in a position to say that it will not prevent Onion Blight. American authorities recommend spraying thoroughly with resin Bordeaux, beginning about the end of June and repeating at intervals of ten days or two weeks throughout the growing season. Other preventive measures: rake up and burn the diseased tops, as by so doing many of the resting spores will be destroyed; if possible, practise a rotation of crops, as the disease is carried over the winter by the resting spores on the ground, and it is believed that they retain their vitality for two or three years; plant onions on well drained land, over which there is free circulation of air.

Black Mould (*Macrosporium parasiticum*, Thiem.): This fungus frequently follows Downy Mildew, causing the dead and dying leaves to become blackened and covered with a thick brownish-black fungus growth. This fungus does not attack healthy leaves and, therefore, its appearance on dead and dying tops should not cause any alarm.

Onion Smut (*Urocystis cepulæ*, Frost): This very injurious disease is, fortunately, not very common in Ontario. Outbreaks of it, however, have occurred from time to time in isolated districts, and onion growers should be on the watch for it in order to prevent it from becoming established in their fields, as the organism which causes it remains in the soil for at least twelve years.

This disease attacks onions grown from seed. It destroys large numbers of seedlings shortly after they appear above the ground. Affected seedlings which are not completely killed in the early stage are so severely injured that they die subsequently or produce small misshapen bulbs. The Smut is also sometimes seen on mature bulbs in the fall. Affected leaves are enlarged and often distorted and dark in color with black streaks. If they are broken they are found to be filled with a black powdery mass, which is composed of the spores of the fungus. Black masses of these Smut spores are also sometimes found on the bulbs.

The fungus which causes Onion Smut is a soil organism, and, as already stated, will remain in the soil for at least twelve years. It can infect the plants only when they are very small. It is carried long distances on the bulbs, and may be spread from field to field on implements and shoes, and washed from high to low land by heavy rains. It may also be introduced into new fields through the use of manure containing refuse from a diseased crop.

Prevention. If the soil is Smut infested, grow the onions on Smut-free soil, then transplant. This is a certain prevention, but involves considerable labor. Rotation of crops will reduce very considerably the amount of Smut. When sowing onions on infected fields apply a formalin solution of the strength of one pint of formalin to 30 gallons of water. This should be applied with a drip attachment on the seed drill at the rate of 125 to 150 gallons per acre (500 to 800 gallons per acre for sets). The same results can be obtained in open furrows by applying the solution with a sprinkler after the seeds are scattered until they are well moistened, then covering promptly with earth.

PEA.

BLIGHT OR LEAF-SPOT OF PEA (*Mycosphærella pinodes* (Berk. & Blax.) Stone): This disease is commonly seen in gardens in Ontario, but seldom causes enough injury to attract attention. It originates from infected seed. Stem, leaves, pods and seeds are affected. Stems of infected plants show discolored areas of dead tissue, sometimes extending completely round them and destroying the shoot. Infected leaves show round or oval discolored spots, from one-eighth to one-half an inch in diameter. On the pods sunken spots much like those of Bean Anthracnose are seen, but pale in color.

The fungus passes the winter as dormant fungus threads (mycelium) in the seed.

Prevention. This is seldom required in Ontario, but if the disease should become prevalent, seed, free from disease, should be sown. This may be obtained by selecting it from healthy pods. Spraying with Bordeaux mixture, beginning when the plants are from two to four inches high and repeating at intervals of five to ten days according to the weather, is also recommended. Such treatment would hardly be worth while on the general crop, but it might be advisable to apply it on a small scale to plants set apart for seed production, since healthy pods bear healthy seeds, and healthy seeds will produce a clean crop the following year.

POWDERY MILDEW (*Erysiphe polygoni*, DeC.): This Mildew usually appears late in the season. Leaves, stems and pods become covered with a whitish or greyish mildew. Later, minute black fruiting bodies (perithecia) are to be seen scattered over the mildewed surface.

Prevention. The disease is seldom serious enough to call for any special treatment, but if it should become prevalent spraying with Bordeaux mixture should control it.

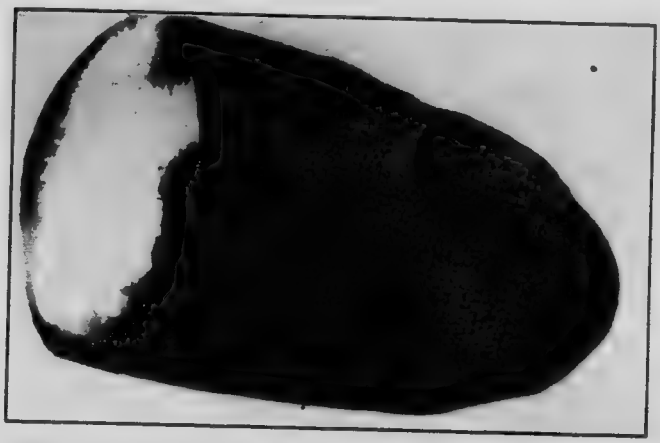
POTATO.

LATE BLIGHT AND ROT OF POTATOES (*Phytophthora infestans*, (Mont.) De Bary): This is the most destructive disease of potatoes in the province. In wet seasons it frequently destroys a large proportion of the crop. The effects of the disease are not noticed usually until late summer—August or September. Frequently, however, if the weather is wet about the middle of July, the disease may be seen in the fields by the middle or end of the month. Conditions which favor its spread and development are wet weather accompanied by relatively low temperatures and excessive moisture in the soil. It is nearly always worse on low, poorly drained lands and on heavy clay soils.

Leaves, stems and tubers are affected. On the infected leaves irregular dark spots or areas are observed. These are usually first seen on the lower leaves, often at the margins. They have a water-soaked appearance when held up to the light. On the under surface of the spots, especially around the margin, a delicate white fungus growth may frequently be seen. In wet weather the spots enlarge and the whole leaf is involved, becomes soft, brown, rotten and droops. In this way the tops may be all destroyed in a few days. In dry weather the spots do not enlarge but become dry, brittle and brown. On the stems brown streaks are sometimes seen. On some of the infected tubers, pits or more or less depressed areas, sometimes with a somewhat purplish tinge and a water-soaked appearance, are seen. If such tubers are cut, brown patches and streaks are found in the flesh beneath.

Infected tubers may dry-rot in the field or in storage. A wet, soft rot, however, usually develops in wet seasons. This is frequently observed when the potatoes are dug, and is thought to be due to organisms which gain entrance to the tubers through the dead areas produced by the fungus which causes the Late Blight and Rot. At harvest time, even if the tops have been badly blighted, there may be very little sign of rot. The tubers, however, are almost sure to be infected, and rot is very likely to develop after they have been stored.

The fungus which causes Late Blight and Rot is spread rapidly through the crop during wet weather by means of numerous spores produced on the lower surface of affected leaves and dispersed by wind and rain. Some of these are washed off the leaves down through the soil on to the tubers, which they are able to infect. The fungus is carried over the winter as fungus threads (mycelium) within infected tubers. Some of these tubers are used for seed, and a few of them produce stunted plants; when these are growing the fungus spreads into the developing shoots, grows up with them, and finally produces the first crop of spores of the



Characteristic Rot due to the Late Blight and Rot Fungus. (After Gussow.)

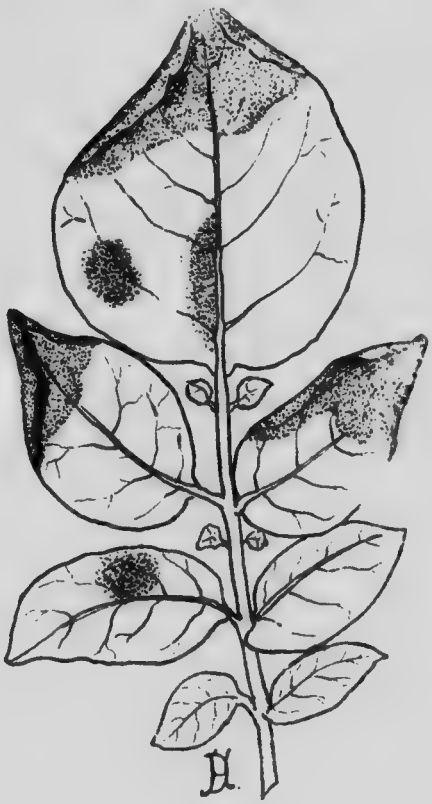
season on their stalks and leaves. From a very few of these infected plants here and there in a field the fungus may spread over the whole crop if climatic conditions are favorable to its development.

Prevention. Spray with Bordeaux mixture. Commence spraying when the plants are from five to eight inches high, and keep the foliage covered with Bordeaux throughout the season. Take special precautions to see that the spraying is very thoroughly done if the weather is at all damp about the 15th of July, as Blight often begins about this time. Add a poison to each application when necessary for Potato Beetles—arsenate of lead paste 3½ pounds to each 40 gallons of the liquid spray, or Paris green 2 pounds to 40 gallons, or a mixture of 2 pounds of arsenate of lead paste and 1 pound of Paris green to 40 gallons. From three to seven applications should be made, depending upon the season; the wetter the weather the larger the number. Do not put off spraying because it looks like rain. If the spray is on the plants half an hour before rain comes it will be dry, and sufficient of it will stick to prevent infection, which takes place during or soon after the rain. Spraying as described above should prevent not only Late Blight and Rot, but also Early Blight and Potato Beetles. For Late Blight and Rot only, it is not

necessary to commence spraying until about the 10th of July; but in Ontario it is usually advisable to spray for all three.

Other means which are recommended to prevent loss from this disease are, planting the more rot-resistant varieties (see O.A.C. Bulletin 239) and avoiding soils which are not thoroughly under-drained, either naturally or artificially.

EARLY BLIGHT OR LEAF-SPOT DISEASE (*Alternaria solani*, E. & M.): This disease is common and in some years causes noticeable damage. It sometimes appears when the plants are from six to eight inches high, but is most abundant



Late Blight.

Early Blight.

about the time the potatoes are in flower. In severe cases the foliage is badly damaged and the tubers remain small. Unhealthy plants and those attacked by the Flea Beetle suffer most from this disease.

Small, scattered, greyish-brown circular spots are first observed on the leaves. These take on a minutely velvety appearance and gradually become larger and run into each other until in some cases half the leaf may become brown and curled. As the spots enlarge faint, concentric rings appear on them, described as "target brand" markings. It is thought that the organism which causes this disease passes the winter as dormant fungus threads (mycelium) in the dead tops and as spores in the soil.

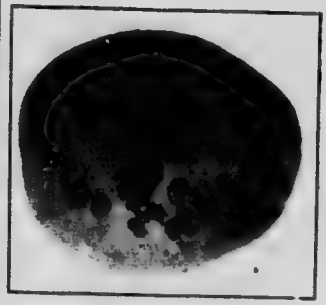
Prevention. Spray with Bordeaux mixture and Paris green or arsenate of lead, as recommended for Late Blight and Rot, giving special attention to the early applications. Rake up and burn diseased tops after the potatoes are dug.

Tip Burn. This is a so-called physiological trouble, that is, it is not due to any organism, but to some condition within the plant itself, probably induced by its environment. It is very frequently seen in abundance in Ontario in hot, dry summers. The leaves brown and curl at the tips and margins. This browning and curling when the trouble is serious may extend to the mid-rib or near it over a considerable portion of the leaf.

Prevention. Keep the soil rich in humus and see that the potatoes are repeatedly and thoroughly cultivated after they are up in the rows to keep down weeds and conserve moisture. Spraying with Bordeaux mixture as for Late Blight and Rot has been found to lessen this trouble.

Common Scab (*Actinomyces cromogenus,* Gasperini): This Scab is familiar to nearly every potato grower. It is easily recognized by the roughened, corky spots

Powdery Scab (after Morse).



Common Scab. (Original.)

on the skin of the tubers. These may be few and scattered or numerous and close together, so as to disfigure badly the potatoes. Sometimes there are also blackened, pocket-like cavities, probably due to mites working in the Scab spots. Scab does not injure the flesh of the tubers to any extent, but renders them unsightly and hence they are not readily saleable.

The organism which causes Common Scab is carried over the winter on seed potatoes and in the soil. A few scabby potatoes in a bag may contaminate the whole lot. The Scab parasite remains in the soil for many years after a crop of scabby potatoes has been produced on it. It will also pass through the intestines of stock fed on scabby potatoes. It thrives best on an alkali soil and is checked by acidity.

Prevention. For seed select smooth, sound potatoes, as free as possible from Scab, and disinfect by soaking them before they are cut for two hours in a solution made by adding half a pint of commercial formalin to fifteen gallons of water. Then spread out on clean grass to dry. Wash all crates, bags, etc., which are used in handling the potatoes in the same solution. The same formalin solu-

tion can be used to treat successive lots of potatoes. Fifteen gallons is sufficient to treat from 20 to 25 bushels if ordinary precautions are taken not to waste too much of the fluid as each lot of tubers is dipped. If the potatoes are not all treated the same day, it is advisable to make up fresh formalin solution for each day's work. If possible plant on clean soil, that is, soil that has not produced a crop of scabby potatoes. Practise a rotation of crops. If Scab is very bad it is not advisable to plant potatoes on the same land oftener than once in five years. Heavy applications of barnyard manure should not be made to the potato crop, but if necessary given at some other point in the rotation. Plant potatoes after clover sod if possible. Avoid alkali fertilizers such as lime and wood ashes. Cook scabby potatoes before feeding to stock.

Powdery Scab (*Spongospora subterranea* (Wallroth), Johnson): This disease was first reported as occurring in Canada about 1912. It was found in Prince Edward Island, Nova Scotia, New Brunswick, Quebec and Alberta. In 1914 it was found in one locality in Northern Ontario. Measures were at once taken to stamp it out. Since that time it has not been found in the Province. It seems safe to conclude, therefore, that at the present time Ontario is free from Powdery Scab. There is great danger, however, of it being reintroduced into the Province on seed potatoes, and those who grow potatoes should be on the watch for it, as it is very undesirable that Powdery Scab should become permanently established in Ontario, since it appears capable of causing appreciable damage to the potato crop.

Tubers infected by the Powdery Scab fungus become covered with conspicuous scab spots, which are more clearly defined, more elevated and smoother on the surface than the spots of Common Potato Scab. When the skin of the scab spot is broken the cavity beneath is seen to be filled with a brownish or greenish powder. As is the case with Common Scab, the chief injury is due to the unsightly appearance of the tubers. In severe cases, however, the potatoes may be stunted and malformed, and it is said that there is always a greater tendency for infected tubers to shrivel in storage.

The fungus which causes Powdery Scab is spread mainly on seed potatoes. It is introduced into new localities chiefly through planting seed which is infected or which has come in contact with infected tubers, or with bags, crates, implements, etc., which have been used in handling them. Once the fungus gains entrance to the soil it will apparently remain there for a number of years.

Prevention. If possible secure seed potatoes from a district known to be free from Powdery Scab. Plant only sound tubers free from Scab and as a precaution disinfect them; use corrosive sublimate rather than formalin for the prevention of this disease. (See directions for the use of corrosive sublimate, page 27.) Such treatment will not render tubers from an infected crop entirely safe for seed, but will destroy spores on the surface and thus prevent the risk of the organism being introduced on healthy tubers which have been in contact with infected tubers or with bags, crates, implements, etc., contaminated with spores. If Powdery Scab is found in a field, report its occurrence at once to the Dominion Botanist, Central Experimental Farm, Ottawa, or to the Botanical Department, Ontario Agricultural College, Guelph, and information will be sent regarding the best method of stamping it out.

Rhizoctonia, Black Scurf (*Corticium vagum*, B. & C. var. solani, Burt.): This disease is very frequently met with in Ontario and in seasons of excessive rainfall often results in a noticeable reduction of the crop. Tubers are very frequently

seen with what appear to be lumps of hardened soil adhering to them. These when wet are black in color. They vary in size from mere specks to one-quarter of an inch in diameter. Sometimes they are very numerous and quite noticeable. They are known as sclerotia, and consist of compact masses of resting fungus threads (mycelium). The flesh of the potato beneath is not injured by them. If tubers, however, with these sclerotia adhering to them are planted, the fungus may spread to the developing sprouts and kill them before they get above the ground, this being one cause of potato failures. Later in the season several other symptoms may develop. Young shoots may wither and die and if these are pulled up and examined there will be found at the base of the stem brown dead areas often encircling it. Sometimes at the base of the stem of affected plants a cluster of small tubers may be found, and very often small greenish potatoes are seen on the stem above ground. Such aerial tubers are very characteristic of the disease, but may result from other causes such as injury to the stem by cultivation. The chief means by which the fungus is spread is through planting potatoes with sclerotia

Hard black lumps (sclerotia) of Rhizoctonia on Potato. (Original.)

adhering to them. The fungus attacks many cultivated plants besides potatoes and very frequently causes the damping-off of seedlings.

Prevention. Since the fungus lives on many different plants, once it gets established in a field it is practically impossible to "starve it out" by a rotation of crops. Care should be taken therefore to avoid as far as possible introducing it into the soil. Disinfecting the seed with corrosive sublimate is recommended. Formalin is said to be unreliable and often worthless for the prevention of this disease. When it is troublesome, select tubers as free as possible from the little hard dark lumps (sclerotia) and disinfect by soaking them before they are cut for three hours in a solution of two ounces of corrosive sublimate in 25 gallons of water. (N.B.—Corrosive sublimate is a deadly poison. Potatoes treated with it are rendered unfit for food).

SOFT ROT AND BLACK LEG OF POTATOES: The diseases to which potatoes are subject are numerous. Various species of fungi are responsible for most of them, but bacteria are involved in some cases. This is particularly so with Soft Rot and Black Leg.

Black Leg of Potato. (Original.)

Black Leg of Potato.

Young potato plants suffering from "Black Leg" or basal stem rot, natural infections. They were from a crop of Davies' Warriors growing in the Experimental plats (O.A.C.), July, 1916. The seed tubers had been carefully picked over and treated with formalin for scab before planting. They were planted on land that had produced considerable rot of the same kind during 1915. Hot dry weather prevailed at the time the plants were picked.

The seed tubers of Nos. 1, 2, 3, and 4, were all rotted away with a wet, slimy rot, at the time the young plants were carefully removed from the soil. A bit of skin with slimy tissue, remains of the seed tuber, is attached to No. 1.

Microscopic examination of portions of rotting stems showed:

No. 1. Heavy bacterial invasion and some Fusarium mycelium.

No. 2. Heavy bacterial invasion and traces of Rhizoctonia mycelium.

No. 3. Ditto, ditto.

No. 4. Ditto, ditto.

No. 5. Heavy bacterial invasion and soft rot of lower part of stem, starting in a bacterial soft, slimy, rotting area of the seed potato; remainder of seed potato still sound. No Rhizoctonia or Fusarium found.

During wet, backward seasons, and in wet, poorly-drained soils, these diseases are liable to be much in evidence.

In the years 1904 and 1905, Prof. F. C. Harrison, then of the Bacteriology Department of the Ontario Agricultural College, made an extended investigation of serious outbreaks of soft rot of potatoes at Guelph and isolated from diseased specimens a bacillus which he named *B. solanisaprus*, which, on inoculation into healthy potatoes, induced soft rot.

About the same time that Prof. Harrison was investigating the disease at Guelph, Dr. Appel, of Germany, was, investigating a disease of young potato stems more or less common in Europe, and he isolated a bacillus from diseased specimens, which he named *B. phytophthorus*. He considered this to be the cause of the potato stems turning black and soft rotting and he named the disease "Black Leg of Potatoes."

It is now considered that the disease described by Harrison as Bacterial Soft Rot of Potatoes and the disease described by Appel as Black Leg of Potatoes are probably one and the same, the term "black leg" applying to the disease when present in the stems of growing potatoes, and the term "bacterial soft rot" applied to the disease in the plant in general, but particularly in the tubers. Harrison found that this organism caused a black discoloration and rot of the stems of young plants, but laid most emphasis on its soft rotting effect on the tubers later in the season. Hence he named the disease "Bacterial Soft Rot of Potatoes."

The following is a partial quotation of Prof. Harrison's description of the disease as published in the Centralblatt für Bakteriologie, 2 Abte. Vol. 17, 1906-7:

GENERAL APPEARANCE OF THE DISEASE IN GROWING POTATOES.

In the majority of cases the first symptoms appear when plants are in full vigour of growth. A plant here and there will present a sickly appearance—drooping leaves, discoloured yellowish. In a few days the stems gradually droop, finally rest on the ground and shrivel up.

When the leaves are turning yellow, black areas may be seen on the stems and petioles, and if these are cut through, the fibro-vascular bundles and adjacent tissues will be found brown or black according to the progress of the disease. The stems are usually most discoloured near the ground. The leaves occasionally turn black without previous yellowing.

The tubers show the most characteristic indications of the disease. Even when the plant appears in a fairly thrifty state, the tubers may be badly diseased, out of all proportion to the apparent vigour of the plant. At first sight, most of the potatoes appear to be sound, but on closer examination the skin over certain areas may be found discoloured a reddish-brown, something like a bruise, with a firm consistency,

Black Leg and Rhizoctonia. (Original).

1. Young potato plants showing Black Leg. The three stems to the left killed; the two to the right badly affected. (Both Rhizoctonia mycelium and soft rot bacilli found in affected parts).
2. Small portion of epidermis from affected areas, showing Rhizoctonia mycelium, low magnification.
3. Small portion (Fig. 2) under high magnification.

but as the disease progresses, the flesh beneath the dark portion becomes soft. There is a sharp line of demarcation between the healthy and diseased portions, frequently marked by a black line, the darker colour being toward the sound part of the potato and gradually shading to a lighter brown on the diseased portion.

On breaking the skin a white, turbid liquid which may contain gas bubbles can be pressed out. This liquid rapidly turns black on exposure to the air. The skin over the diseased area easily peels away and the exposed flesh is watery and white, but soon discolours in the air, becoming almost black. In later stages of the disease the flesh softens to a watery pulp and becomes highly offensive with a putrefactive odour. In the final stage the potato becomes a mass of black soft pulp.

Several modifications of these conditions may be noticed. Thus the discolouration and blackening may be confined to only one portion of the tuber, and at other times the whole of the tuber beneath the skin is softened and discoloured with the centre portions quite sound. In some cases the most rotten tuber was the seed potato, in others the new potatoes.

The rot seemed to extend from the one first infected to the rest, infection evidently caused by actual contact.

If the potatoes are allowed to dry out, the tissues between the healthy and already softened portions undergo a corky modification.

After the potatoes are dug, and the apparently sound ones are put into a cellar or pit, the disease continues to spread, and in cutting open affected potatoes they will be found with brown or blackened areas. Such areas are not confined to the fibro-vascular ring, but may be of any size and in any portion of the potato.

Natural Method of Infection. One of the principal means of infection is the diseased condition of the seed potato when planted. In a large number of plants examined in the field the seed potato was found to be badly rotted and the young potatoes around were infected on the side nearest the rotted tuber. While it is doubtful if the potato rot bacillus can penetrate the unbroken epidermis, yet, if a small amount of rotted potato is placed on the unbroken surface of a healthy tuber, it will in a short time cause infection. This is probably due to the large amount of cytase in the rotted mass, which is able to bring about a solvent actior on the cement substance of the cells of the healthy potato.

In the event of the organism being in the soil, infection may take place through wounds made while cultivating.

During the season of 1915 Black Leg and Soft Rot of Potatoes was very common in many districts in Ontario. The writer received many specimens of diseased plants from Peel, Norfolk, Lambton, Grey, Dufferin, Nipissing, Simcoe and Brant counties, and devoted considerable time to a study of the disease throughout the season as it developed in the neighborhood of Guelph. Bacilli were isolated from some specimens very similar to the species described by Prof. Harrison, which, on inoculation into growing potato stems produced Black Leg and when inoculated into tubers produced a soft, slimy rot.

Many of the specimens of Black Leg examined, however, were also affected with the fungus Rhizoctonia, and from continued observations and a number of experiments conducted during 1915 and 1916, the writer came to the conclusion that most of the trouble with Black Leg during those seasons was due primarily to affection of the young sprouts from the seed potatoes with this fungus, followed by invasion with the bacteria.

This being the case, it will be advisable to pay particular attention to the seed potatoes to see if they are affected with the sclerotia or Black Scab, which Rhizoctonia produces on the tubers. For treatment for seed potatoes so affected, see the article on Rhizoctonia on page 27.

Control of the Disease.

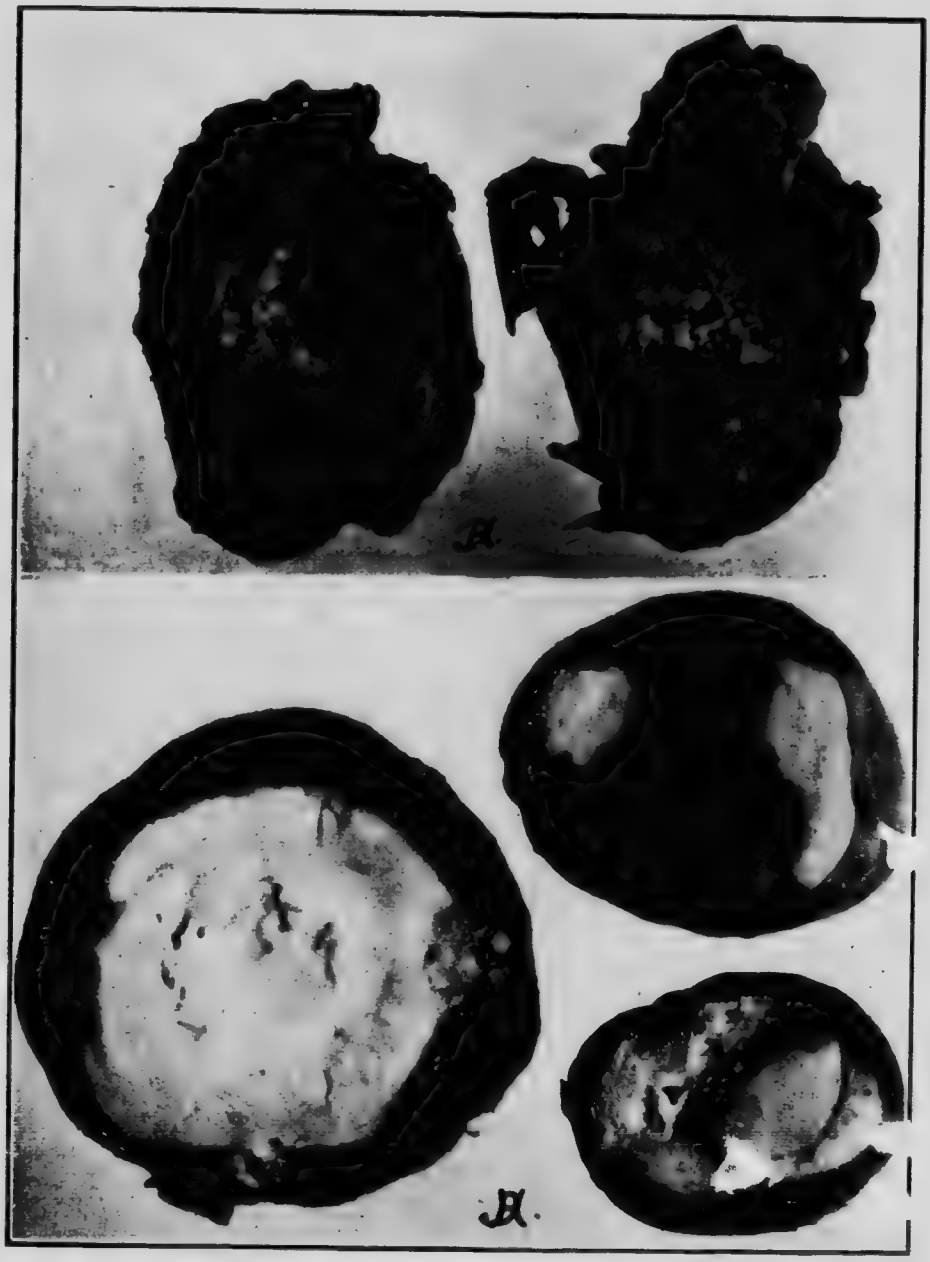
1. Do not plant potatoes that show any brown discoloration or other indications of either wet or dry rot.

2. Plant in well-drained land.

3. Carefully remove from the soil and destroy by burning all diseased plants and tubers.

Potato Tubers, showing Bacterial Soft Rot in various stages of development, some tubers entirely rotted, others only partially affected. (Original).

1. Six tubers that contracted the disease directly through the stem from the parent plant.
2. Six tubers that contracted the disease at the eye end from coming in contact with other diseased tubers.



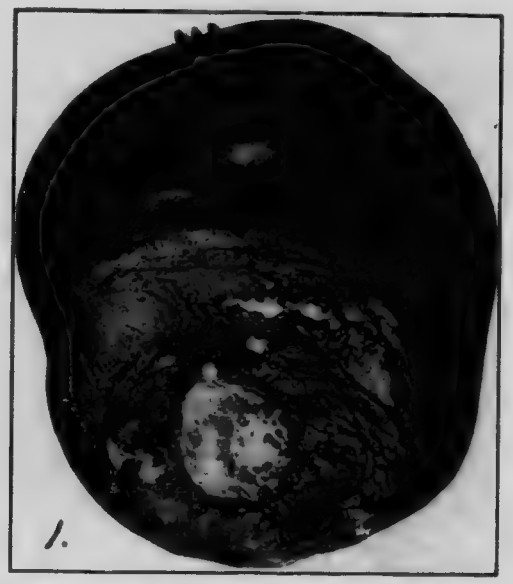
Tubers in advanced stages of the Bacterial Soft Rot, taken directly from the field. (Original).

4. On land where the disease has been prevalent, do not plant potatoes or tomatoes for several years, as both B. solanisaprus and Rhizoctonia will live in the soil a considerable time, how long has not been determined.

5. Soak seed potatoes before cutting for 3-6 hours in corrosive sublimate solution, 1 ounce to 10 gallons of water in a wooden vessel (corrosive sublimate is a strong poison), or in formalin solution of 1 pint of formalin to 30 gallons of water for 2 hours.

6. When cutting seed potatoes, have two or three knives and a jar containing disinfectant on hand. After cutting into a tuber which shows brown discoloration inside, drop the knife into the disinfectant, discard the diseased tuber, and take a fresh knife for the next cutting.

Fusarium Wilt and Dry Rot (*Fusarium oxysporium*, Schlecht): This disease appears to be common in the province. The chief loss is due to the dry



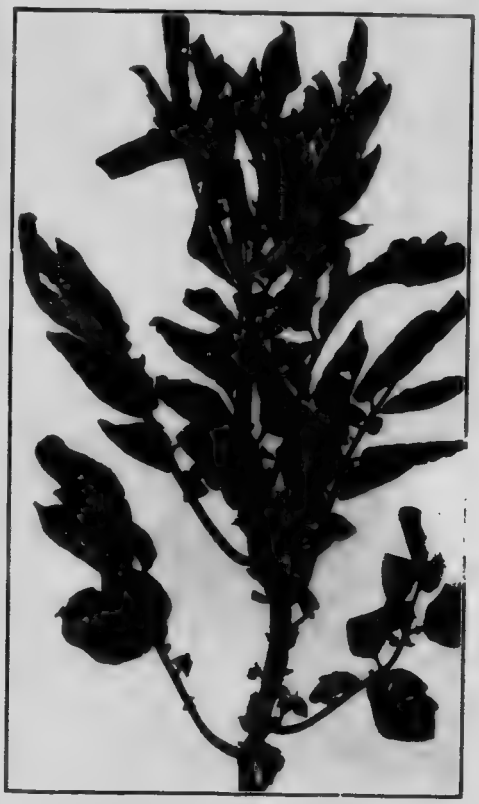
Fusarium Dry Rot of Potatoes. (Original.)

rotting of potatoes in storage. The fungus which induces it invades the underground parts of the plant, causing the foliage to become unhealthy in color and finally curl, wilt and die. This wilting of the tops is seldom prevalent enough in Ontario to attract much attention. In storage affected tubers are often noticed. These show a peculiar shrivelling and dry-rotting of the stem-end. Some of the affected tubers, however, may have no external evidence of the disease, but when cut a brownish or blackish ring is seen at the stem-end in the flesh, about one-quarter of an inch below the skin. However, not all tubers with this discolored ring at the stem-end are affected by this disease. The writer has examined tubers with this ring extending for a short distance from the stem, but they proved to be entirely free from any fungus. The cause of the discolored ring in such cases is unknown. It does not appear to develop further in storage. When the ring is due to the Dry Rot fungus some of the tubers will have indications of shrivelling at the stem-end and there will be more or less development of the characteristic Dry Rot in storage.

Prevention. Wilted plants should be dug up and destroyed whenever noticed during the summer. Potatoes with the discolored ring at the stem-end should not be used for seed. Do not plant potatoes again for several years in a field which has produced a crop badly affected with Fusarium Wilt and Dry Rot. Spraying will not prevent this disease nor will treating the seed with formalin.

Potato Canker or Wart Disease of Potatoes (*Chrysophlyctis endobiotica*, Schilb.): This disease was found in Canada in 1912, and prompt measures were taken to stamp it out. These were apparently effective, as it is not known to exist in the Dominion at the present time. It is a very serious disease and it is therefore important that Ontario growers should be able to recognize it, in order

Potato Canker. (After Gussow.)



Leaf Roll. (Photo by R. E. Stone.)

that they may report its presence promptly should it at any time appear in their crop.

Potato Canker is not usually observed until harvest time. Badly affected tubers are simply brownish-black masses of warty excrescences, not in the least resembling potatoes. Tubers showing the early stages of the disease have some of the eyes slightly protruding and composed of simple or compound groups of small nodules, brown in color. At this stage the disease is very likely to be overlooked by the casual observer.

Prevention. Be on the watch for this disease and if suspected potatoes are found, send samples to the Dominion Botanist, Central Experimental Farm, Ottawa, or to the Botanical Department, Ontario Agricultural College, Guelph.

LEAF ROLL: The cause of this disease is unknown. It has been observed in numerous fields in the potato growing districts of Old Ontario. In some fields examined this summer (1917) over 60% of the plants were affected with Leaf Roll.

Experiments and observations show that Leaf Roll may reduce the yield to a very marked extent. In experiments conducted by Mr. Murphy, Assistant in Charge of the Dominion Field Laboratory of Plant Pathology at Charlottetown, P.E.I., it was found that the average yield of plants diseased with Leaf Roll in Prince Edward Island is 1.66 ozs., while healthy plants of the same variety yield 19.0 ozs. The corresponding yields per acre would be 26 bushels and 297 bushels.

*Symptoms of Leaf Roll are very variable. Affected plants are always more or less dwarfed and in some varieties the leaves assume a characteristic upright, almost staring habit instead of drooping over in the normal way. This symptom is sometimes absent, the plants presenting instead a low-headed, bushy appearance. When the crop is badly affected the poor growth of the foliage is very noticeable. It is practically never as green on affected plants as on healthy ones and occasionally on certain varieties it takes on a purplish or reddish color at the tips and around the margins of the leaves. Rolling of the lower leaves is always associated with the disease. This is often rather inconspicuous and may not extend beyond the leaves lying close to the ground, although it may affect the intermediate and even the topmost leaves. Marked rolling of the upper leaves, however, is often seen on plants not affected with Leaf Roll. The rolled leaves on plants affected with this disease begin to die early. The harsh, leathery texture of such leaves is a constant symptom. This point may be tested by feeling them with the fingers. The tubers of affected plants are small and are borne generally on very short tuber-branches (stolons) or even attached in a cluster to the stem.

Leaf Roll is chiefly transmitted through the seed. Tubers from affected plants invariably produce diseased plants. There is also evidence to show that the disease may spread from plant to plant in the field. Just how is unknown, as up to the present time no parasite has been found associated with Leaf Roll.

Prevention. The surest way of avoiding loss from Leaf Roll is to secure fresh seed from districts free from the disease. Fortunately, this is possible, as Northern Ontario and certain sections of New Brunswick, Nova Scotia and Prince Edward Island are comparatively free from this trouble.

MOSAIC: The cause of this disease is also unknown. It has been observed in many fields in Ontario. When it is severe there is a very noticeable reduction in the crop.

*The foliage of plants affected with Mosaic is somewhat wrinkled or corrugated and mottled, with faint, light green or yellowish spots. These symptoms vary considerably, being well marked in some cases and not so noticeable in others. The stalks of diseased plants are often more bare near the ground than those of healthy ones, partly because the affected foliage does not spread out and droop down normally and partly because the lower leaves sometimes fall off in the last stages of severe attacks. The tubers of affected plants are normal-looking and sound and their keeping or eating qualities are not impaired.

Like Leaf Roll, Mosaic is transmitted through the seed and is spread very largely by the use of seed from diseased plants. It is also thought to be spread from plant to plant in the field, probably by insects as is the case with related diseases.

*** Adapted from description supplied by Paul A. Murphy.**

Prevention. If the disease is not very prevalent in a field, remove the affected plants so as to secure ed as free as possible from Mosaic. If the Mosaic is very abundant, secure fresh seed from a field or district free from the disease. It may be necessary to discard susceptible varieties in order to avoid loss from Mosaic.

Curly Dwarf: Another disease of unknown cause, frequently met with in Ontario, especially in unthrifty fields of potatoes. It appears to cause a very noticeable reduction in the crop. Plants affected with Curly Dwarf are stunted and the foliage is markedly curled and wrinkled. This disease is known to be transmitted through the seed.

Prevention. Remove affected plants so as to secure seed free from Curly Dwarf or secure fresh seed from a field or district free from the disease.

TOMATO.

Leaf-Spot or Blight (*Septoria lycopersici, Speg.*) The most destructive disease of tomatoes in Ontario. It attacks the leaves and stems of tomatoes, and it is very hard to control.

Small, greyish-brown, angular spots containing minute black specks appear upon the leaves and stems. The lower leaves are first attacked, and the disease spreads upwards, often almost completely destroying the foliage of the plants. The organism which causes the disease is carried over the winter in the soil of the field, greenhouse or hotbed.

Prevention. Spray with Bordeaux mixture (4.4.40 formula), commencing when the plants are in the seed bed and repeating at intervals of ten days or two weeks until there is a danger of staining the fruit. With small patches of tomatoes it is often advisable to stake and tie up the plants for greater convenience in spraying. The diseased tops should be raked up and burned, and, if practicable, a rotation of crops should be followed.

Leaf Mould, Scab (*Cladosporium fulvum*, Cke.): This disease sometimes causes injury to tomatoes under glass. It is easily recognized by the olive-brown, felt-like fungus growth which is seen on the upper side of the leaves, and is accompanied by brown discolorations on the lower surface. In severe cases the leaves may turn brown, shrivel and die.

Prevention. Proper ventilation of the forcing house is the best preventive. Spraying with Bordeaux mixture at intervals of ten days or two weeks will hold this disease in check, but is seldom necessary when proper ventilation is provided, so that the foliage of the plants does not become excessively moist.

Blossom End or Point Rot: This is another of the so-called physiological diseases, not being due to any organism, but to some condition within the plant itself, probably induced by its environment. It is sometimes seen in Ontario, and has occasionally been reported as causing serious loss by rendering useless tomatoes both under glass and in the field. It was very prevalent this summer (1917). The fruits only are affected.

The first symptom of the trouble is the appearance of irregular, water-soaked areas near the tip of the fruit, usually when it is about half-grown. These water-soaked areas later become flattened or sunken and dark green to dark brown in color, and of a hard, leathery texture. Various fungi and bacteria may gain entrance through these injured spots and induce rot, which may destroy the whole fruit.

Prevention. There is very little exact knowledge concerning the cause or the control of this disease. Over-forcing of the plants, especially in the early stages

of their development, irregular watering and heavy applications of farmyard manure seem to make the plants liable to develop the trouble. Outdoors it is usually worst on light, sandy soils.

TOMATO MOSAIC: A disease of unknown cause frequently seen in Ontario, both in the field and under glass. The leaves of affected plants may be mottled with light green or yellow, or they may be dwarfed and have a peculiar, fern-like appearance. Sometimes the leaflets are so narrow and slender as to appear almost thread-like.

Prevention. As yet there appears to be no satisfactory method of controlling this disease. It is well known that it can be transmitted from plant to plant, and

Leaf Spot of Tomato. (Attacked leaves and stem).
(From Ohio Bulletin 73).

that it frequently spreads through th ds when tomatoes are grown under glass. There is some evidence that it may persist from year to year in the soil in the greenhouse. Any tomato plants growing under glass showing symptoms of Mosaic should be pulled up at once and burned, in order to prevent the disease from getting established in the house.

BACTERIAL SOFT ROT OF VEGETABLES: Bacterial soft rot is a disease liable to attack fleshy vegetables and flowers, particularly carrots, cauliflower, turnips, celery, tomatoes, potatoes, German iris and calla lily, and in a lesser degree onions, asparagus, salsify, sugar beet, mangel, muskmelons, and some others. Occasionally the disease results in heavy losses to the grower of these crops.

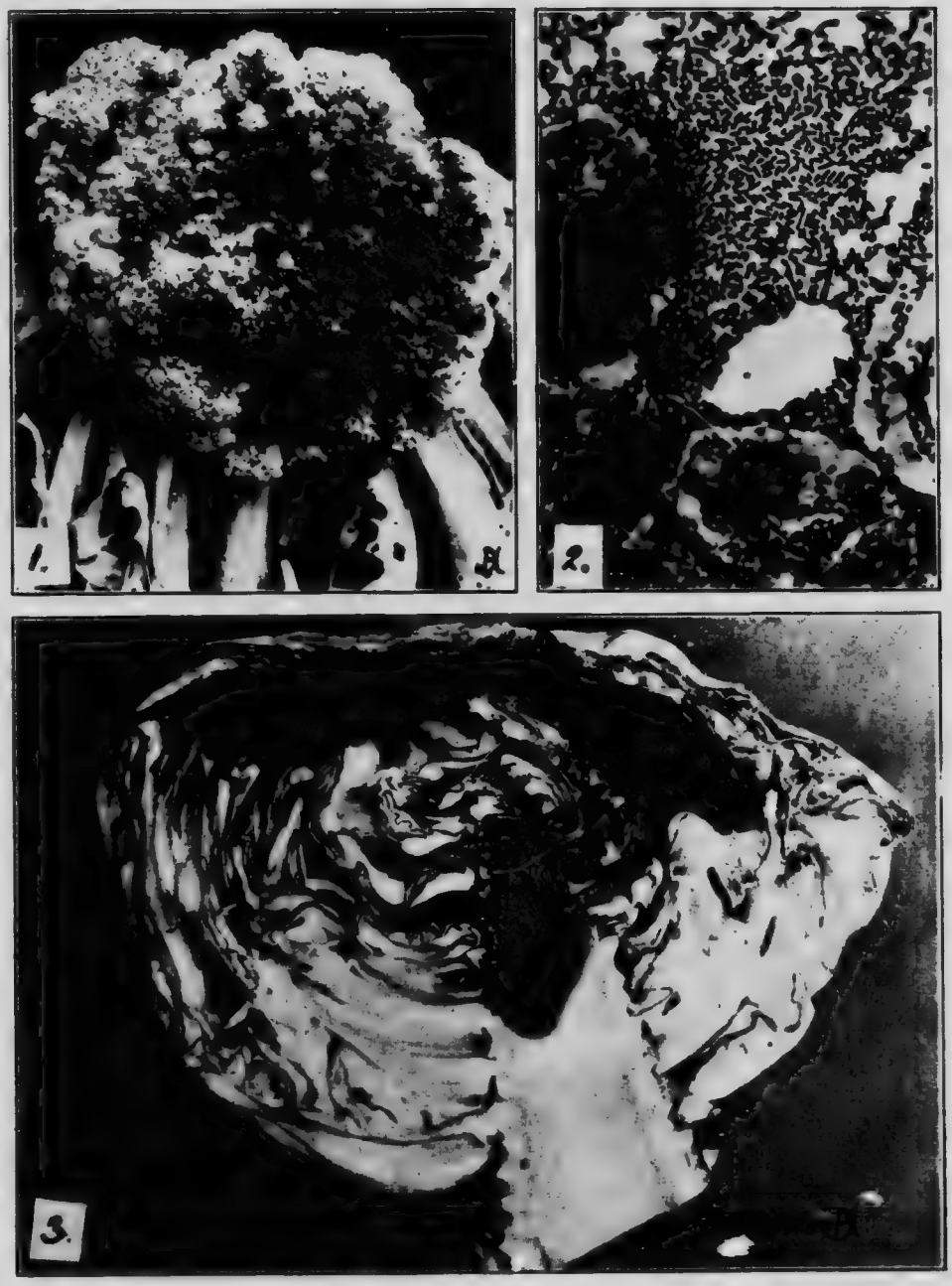
General Appearance of the Disease. As the name signifies, the disease results

in a soft, wet rot of the plant attacked. The rotted portion of the plant is darker in color than the rest of the plant. The color of the diseased part varies from a light, reddish-brown to a very dark brown in the case of white or creamy fleshed plants, such as cauliflower, turnips or heart of celery, and a very dark green, almost black, in case of the green tissues which are attacked. The diseased tissue is very soft and mushy, and frequently has a strong and offensive odor. There is a clear line of demarcation between the diseased and healthy tissues, the disease inducing complete destruction of the tissue as it advances from the point of inoculation.

Cause of the Disease, B. carotovorus, L. R. Jones. (The Vegetable Soft Rot Bacillus.) The cause of the disease is a bacillus which has been given a variety of names by different men, who at different times in various countries have studied the disease in different species of plants. Prof. L. R. Jones, of Vermont, studying the disease in a crop of carrots, named the casual organism *Bacillus carotovorus.* Prof. Harrison, of Ontario, studying the disease in an outbreak in a crop of cauliflower, named it *Bacillus oleraceæ;* Prof. Potter, in England, studying the disease found it to be destructive to quite a number of varieties of plants, and named it *Pseudomonas destructans;* N. J. Giddings, of Vermont studying the disease in a crop of melons, named it *Bacillus melonis;* C. O. Townsend, of Washington, studying the disease in a greenhouse of calla lilies, named it *Bacillus aroideæ.* More recent investigations have shown that the disease is practically one and the same in all the plants mentioned. While to the bacteriologist there may be a few slight differences in the nature of the bacillus causing the disease in the melon from that causing the disease in the lily, or that causing the disease in carrots, turnips and cauliflower and other vegetables, yet the disease is for all practical purposes to the horticulturist one and the same—soft, wet rot of the plant attacked.

Blossom End or Point Rot of Tomatoes. (Original.)

Histology of the Disease. When the soft rot bacillus gets on to a freshly made wound, either small or large, in plants liable to the disease, it feeds on the plant juice which emerges on to the wounded surface, and on it is grows and rapidly multiplies. As it multiplies it produces pectinase, a cytolytic enzyme which dissolves the middle lamellæ, the thin strip of tissue which lies between adjacent plant cells. The lamellæ are quickly dissolved and form good food for the multiplying bacilli, which, as they multiply, pass along between the cells, filling the intercellular spaces and separating the cells from one another. The protoplasm within the plant cells is plasmolised, that is, it is made to shrink from contact with the cell walls and to contract into an irregular mass within the cell, by the action of the enzymes produced by the bacilli in the intercellular spaces. In this way the collapse of the tissue is brought about, and such tissue constitutes the rotted part of the plant.

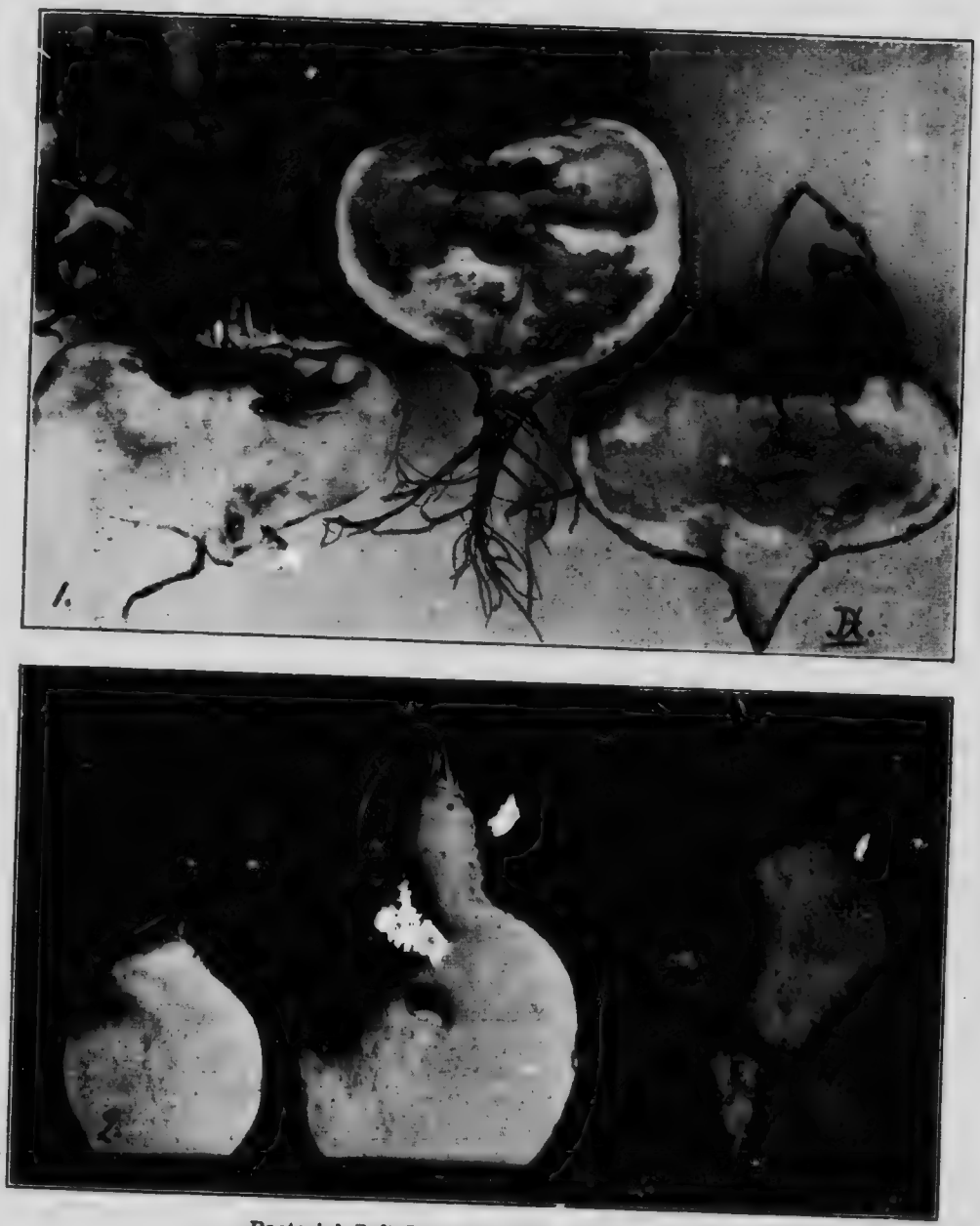


Bacterial Soft Rot of Cauliflower and Cabbage. (Original.)

1. Bacterial soft rot of cauliflower, natural infection; specimen taken direct from garden.

2. *B. carotovorus*, the vegetable soft rot bacillus seen between cells of broken-down, rotting cauliflower. (x 1000 di.)

3. Bacterial soft rot of cabbage. Artificial stab inoculation of a pure culture of *B. carotovorus* in healthy cabbage. Photo taken twenty days after inoculation.



Bacterial Soft Rot of Turnip. (Original.)

1. Turnips direct from field badly affected with bacterial soft rot. Shaded areas were soft, pulpy and strong smelling. Evidently inoculated near the crown, probably through wounds made by slugs or caterpillars or during cultivation.

2. Soft-rotting turnips direct from field, in which the disease had been prevalent the previous year. These had evidently been inoculated from the soil through wounds made while hoeing or cultivating.

In *Cauliflower* the disease is found more often in the flower than in the leaves or stem; the latter parts, however, are also subject to attack.

The disease in the flower is very easily noticed, the normal color of the flower being white or creamy and that of the diseased portion light to dark brown and very soft, and having an offensive odor. The writer has noticed a number of times dark brown areas varying in size, which looked at first sight like soft rotted areas, but which, on investigation, proved to be discolorations due to excreta of cabbage caterpillars, which had been feeding on the leaves overhanging the flower. In such cases the tissue immediately below the surface of the discolored area is not softened as it is in the case of the rot, and the discoloration is only on the surface. Observations have shown, however, in a number of such cases that the rot has later developed within such discolored area, thus indicating that in all probability the caterpillar had previously been feeding on a rotted plant, and all the bacilli in the portion consumed had not been killed in the process of digestion, but had passed through the alimentary tract of the caterpillar with the excreta, or that the mouth parts and feet of the caterpillar had been contaminated from a diseased plant, and on crawling over the surface of the healthy plant had inoculated it.

In the stem the disease results in a complete softening of the interior, the softened tissue becoming a dirty grey in color with strong odor. The disease may enter the stem from injury to the exterior caused by the breaking of leaves, or the biting of insects, slugs and caterpillars during cultivation, etc., and from the stem pass up into the flower, or the stem may become so far rotted that the head will fall off. The stem may also become infected through the flower.

In the leaves the disease is more often found in the petiole or midrib rather than the blade. It appears as a dirty grey, softened area, which, when in the petiole, soon results in collapse of the leaf.

In *Turnip* the disease most frequently enters at or near the crown through caterpillar or slug attack, or through injuries received during hoeing or cultivation. It softens or rots the leaf petioles at their base, causing them to fall over, and spreads slowly in dry weather, rapidly in wet weather, through the tissue of the root, inducing a brown colored soft rot with strong odor.

In *Carrot* the disease enters and develops in much the same way as described for the turnip. It is more apt to spread rapidly through a crop that is thickly sown and not well thinned out, the shade produced by the heavy tops making ideal conditions by keeping the ground moist for the development of the disease when once it gains entrance, and harboring slugs and caterpillars that spread the disease. Carrots which crack beneath the ground are liable to be attacked by the disease, the soft rot bacillus gaining entrance to the tissue through the cracked surface.

In *Celery* the disease is not very common, but when present is most often found starting at or near the tops of the young growth. The affected parts become dark brown and very soft and mushy. The parts so affected cease growing, the growing tips being destroyed, and the disease slowly passes down the stem, completely rotting the tissue as it progresses. If the disease starts below the end of the stem, the upper part soon topples over as a result of the softening of the part attacked. The disease spreads from plant to plant through the agency of slugs, caterpillars, etc., and during the process of handling when cultivating and banking up. When the plants are stored away for winter use, if a plant having the disease is stored with the healthy plants, the rot is liable to spread to the healthy specimens.

In *Tomatoes* the disease is very common during wet seasons. It is found most frequently in the fruits that are in contact with the soil after they have commenced to ripen. The bacillus will not readily penetrate through the unbroken skin of the tomato. But when a tomato is resting on the damp earth, that part of the skin

Bacterial Soft Rot of Celery. (Original).

1. Artificial needle inoculation of pure culture of B. carotovorous (isolated from rotting cauliflower) into the young and vigorous growth of celery. Five days after inoculation, kept at 25° C.
2. Same as Fig 1, five days later.
3. Same as Fig. 1, ten days later.
4. Same as Fig. 1, three weeks after inoculation, showing complete collapse of plant.
5. B. carotovorous, the vegetable soft rot bacillus, between the cells of rotting celery tissue (x 1000 di.).

in contact with the soil is frequently weakened, thus providing a means of access to the bacillus. This, however, is not the only means whereby the disease enters the fruit. Slugs are very partial to tomatoes just ripening. In their attack on the fruit they eat through the skin, leaving the interior flesh exposed. This exposed surface is an ideal medium for the bacillus of soft rot to develop in. The writer has found many tomatoes, particularly in wet seasons, when slugs are plentiful, that have contracted the disease in this way.

Eradication and Control of the Disease. Spraying with fungicides, which is so effective in controlling the fungus diseases of plants, is of no avail with bacterial diseases, as the bacteria which cause the disease act in the interior tissue rather than on the surface; hence the spray will not reach them.

Spraying with insecticides is helpful indirectly, as it tends to keep in check the insects, slugs, caterpillars, etc., which are one of the most common means of spreading bacterial diseases from one plant to another.

As a rule the best method to adopt in dealing with a plant affected with bacterial disease is to carefully remove and burn it. Insects, garden tools, etc., coming in contact with it, will spread the disease to the plants with which they come in contact later. This is particularly the case with the bacterial soft rot of plants, as the affected tissue is so very soft and pulpy that it cannot be touched without heavily contaminating whatever touches it.

Again, if affected plants are allowed to remain on the ground they infect the soil with the organisms of the disease to such an extent as frequently to cause the disease to establish itself in the succeeding crop of any plants which are susceptible to the disease, but particularly plants of the same species.

Some time ago we received for examination a box of rotting, half-developed turnips from a farmer, who said that five per cent. of his crop were similarly affected. Upon enquiry we found that the affected ones were growing on soil on which turnips had been grown the year previous, and 25 to 30 per cent. of these having been affected with the same rot, had been allowed to remain on the ground at harvest time, and later were plowed in. It was evident that the soft rot bacilli from the diseased turnips had remained alive in large numbers in the soil, and that many of the turnips of the subsequent crop had been inoculated with these bacteria during cultivation and possibly by insect attack also, see page 41. The hoe or the teeth of the cultivator would get contaminated from the soil, and accidental wounding of a turnip with such an implement would result in the inoculation of the turnip with the germs of the disease.

Another man sent a head of celery for examination, which we found to be suffering from the bacterial soft rot in the young growing tips. In reply to our enquiries he sent word as follows: "I had celery on this ground two years ago, and the row that was where the rot is worst now was so bad then that I lost all, but only that row was affected. This year two rows had it, but one a great deal worse than the other. There were five rows in this patch all planted about the same time. The healthy rows matured away ahead of the two which were diseased." Here it is evident that the soft rot bacteria had remained in the soil for two years, and that cultivation had spread the bacilli to some extent through the soil, as on the second occasion that celery was grown on that patch the plants in two rows developed the disease.

The writer had under observation a garden where turnips and carrots were both affected with the bacterial soft rot. The affected plants were not removed, but were dug in. The next year tomatoes were planted on the same ground. The disease did not develop in the growing plants, as care was taken not to wound them. However, about 60 per cent. of the fruit became affected before it was fully

ripe. The affected specimens were either those that were in contact with the soil or had been bitten by slugs. The soft rot bacteria, which cannot penetrate through the sound skin of a tomato, found entrance through the slug bites or through the weakened skin that had been in contact with the soil.

Therefore, in order to prevent losses from bacterial soft rot of plants, remove and burn affected plants, or parts of plants, as soon as observed; be careful during cultivation not to wound plants, and keep caterpillars, slugs and biting insects in check. Affected plants should never be put on the compost heap or manure pile.

Harvesting and Storing. When harvesting and storing turnips, cauliflower, cabbage, celery, tomatoes or other vegetables from crops in which the disease has been present, great care should be taken not to include any specimen that shows the slightest appearance of the disease, or to smear the healthy specimen with the soft rotted parts of diseased specimens. If these precautions are neglected, the disease is liable to establish itself and spread more or less rapidly through the entire crop stored.

Damping-off of Seedlings.

The seedlings of many plants are liable to be affected by a disease which weakens the stem at or near the ground, causing the plant to fall over and ultimately die. Several different species of fungi cause this trouble, which is commonly known as Damping-off. Rhizoctonia, species of Fusarium and Pythium de Baryanum are among the commonest of the fungi inducing this disease.

Prevention. For a seed bed secure well-drained soil not previously infested with the disease. Avoid thick sowing, shade and over-watering. Affected plants should be removed as soon as noticed, together with the adjacent soil. When the disease becomes troublesome in greenhouses, if the soil cannot be renewed, it should be sterilized with steam or formalin as described on page 47.

FUNGICIDES.

The principal fungicide used for vegetables is Bordeaux mixture. Lime-sulphur has been tried for the control of Late Blight and Rot of potatoes and for Blight on celery, but has not given satisfactory results.

Formalin and corrosive sublimate are quite extensively used for the disinfection of potato tubers and vegetable seeds, in order to prevent certain diseases, the germs or spores of which are carried over from season to season adhering to them.

Bordeaux Mixture.

Formula.

Copper sulphate (Bluestone)	**4 pounds**
Unslaked Lime	**4 "**
Water	**40 gallons.**

Dissolve the copper sulphate in a wooden or brass vessel with hot water. Pour into a barrel and add cold water to make 20 gallons. Slake the lime, preferably with hot water, and add cold water to make 20 gallons. Stir both barrels well and pour the lime into the copper sulphate solution. (Never mix concentrated milk of lime and copper sulphate solution.)

A stock solution of each may be made, and can be kept indefinitely if not

mixed. Dissolve 40 pounds of copper sulphate in 40 gallons of water by suspending just below the surface of the water in a coarse sack. Each gallon of the liquid will now contain one pound of copper sulphate. Slake 40 pounds of lime in hot water, then add cold water to make 40 gallons. Each gallon of the solution will now contain one pound of lime. A tub or half barrel will be found most handy for slaking the lime in. It is often more convenient to work with smaller quantities of the stock solutions, such as 20 pounds of copper sulphate or bluestone to 20 gallons of water and 20 pounds of lime to 20 gallons of water.

When stock solutions are prepared Bordeaux mixture of the required strength (4.4.40 formula) can be made up directly in the spray pump barrel by filling it half full of water (20 gallons), then adding two gallons of the stock solution of copper sulphate and two gallons of the stock solution of lime, after which the barrels can be filled with water nearly to the top and two more gallons of each of the stock solutions added. The barrel after this should be full. If it is not, add more water. If a tank larger than a 40-gallon barrel is used proportionate amounts of the stock solution should be added when half full of water and when nearly filled. Stir the stock solutions well and strain them when putting into the spray pump barrel.

To test the Bordeaux mixture let a drop of ferrocyanide of potassium fall into a little of the mixture in a saucer. If this causes it to turn reddish-brown add more lime until no change takes place.

Resin Bordeaux.

The surface of some plants like onions, cabbages and asparagus, is so smooth that Bordeaux will not readily stick to it. This makes effective spraying difficult. This difficulty, however, may be overcome by using the following preparation:—

Resin	2 pounds.
Sal Soda crystals	1 pound.
Water	1 gallon.

Boil together in an iron vessel (preferably out of doors) until the mixture is of a clear brown color. This will take from one to one and a half hours. Add the above quantity to each 40 gallons of Bordeaux mixture.

Formalin.

Formalin is a clear liquid disinfectant. It is a 40% solution of formaldehyde gas in water. It can be purchased from almost any druggist, and costs from 25c. to 50c. per pint. It is sold under the names of "formalin" and "formaldehyde." It is important that the purchaser, whatever name he buys it under, secures a guaranteed solution of full strength 40% formaldehyde. The stock solution should always be kept in a well-corked botte. Formalin, when diluted with water for treating seed potatoes, is not a dangerous poison, although the strong fumes will make the eyes smart, and a strong solution will harden the skin temporarily.

For Potato Scab soak the tubers before they are cut for two hours in a solution of ½ pint of formalin to 15 gallons of water.

For Black Rot of cabbage and cauliflower, soak the seed for 15 minutes in a solution of ½ pint of formalin to 15 gallons of water.

For Onion Smut 1 pint of formalin to 30 gallons of water, applied as directed on page 21.

Corrosive Sublimate (Mercuric Chloride).

Corrosive sublimate may be obtained from any druggist. It is a deadly poison, and should be so labelled, and kept out of the way of children and stock. It is usually sold in the form of tablets, one of which dissolved in a pint of water gives a solution of the strength of one part by weight of corrosive sublimate to 1,000 of water. It is not very readily soluble, and hot water should be used to dissolve it. It corrodes metal and, therefore, should be mixed in wooden or earthen vessels. It is an excellent disinfectant, but even in dilute solutions it is deadly poison. Great care, therefore, must be used in handling it. Potatoes disinfected with it should never be used for food for man or beast, and vessels which have contained it should be very thoroughly washed with hot water before they are used for any other purpose.

For disinfecting seed potatoes to prevent Black Leg, Rhizoctonia and Powdery Scab of Potatoes, soak the tubers before they are cut for three hours in a solution of corrosive sublimate of the strength of 1 part to 2,000 of water. For Club Root of cabbage and Black Rot, cauliflower and turnip, soak the seed for 15 minutes in a solution of corrosive sublimate of the strength of 1 part by weight to 1,000 of water. Corrosive sublimate can be used effectively for the prevention of the common Potato Scab, but it is not recommended here, as formalin is a safer and just as reliable a disinfectant for this purpose.

STERILIZATION FOR GREENHOUSE SOIL.

This is often required in order to rid the soil of fungi, which live over from year to year in the beds and cause disease of the crops grown on them. Lettuce Drop, Rhizoctonia and Damping-off are among the diseases which can be prevented by soil sterilization.

Steam sterilization is the most satisfactory. What is known as the "inverted pan method" is the one which is most generally used in greenhouses. The apparatus consists of a galvanized iron pan about 4 ft. x 10 ft. and 6 inches deep. This is inverted over the soil to be sterilized, the steam being emitted through a hose connection at one end of the pan The sharp edges are forced down into the soil to prevent the steam escaping. Fertilizers should be applied before the sterilization is done. The steam should be kept at as high a pressure as possible, 80 to 100 pounds, and the sterilization continued from three-quarters of an hour to one and one-half hours, depending upon the pressure maintained. This treatment will destroy both spores of fungi and [illegible]ed seeds in the soil.

Sterilization with Formalin. This method can be employed when live steam is not available. All plants should be removed from the beds and the earth thrown up loosely. The soil should be dry when the sterilization is done. The formalin is diluted in water, 2 pounds to 50 gallons. This solution should be applied to the soil at about the rate of 1 gallon to the square foot. Two men can do this work best, one man applying the solution with an ordinary sprayer or watering can, the other man spading over the soil as the solution is applied. As soon as the soil can be worked without puddling after treatment, it should be thrown up loosely to permit the evaporation of the formaldehyde. The beds should not be planted for about two weeks after treatment, and before planting is done they should be thoroughly spaded over several times. When live steam is available, the "inverted pan method" as described above, will be found much more satisfactory than the formalin sterilization.

HOST INDEX

PAGE

ASPARAGUS:
- Rust . . . 3

BEANS:
- Anthracnose or Pod Spot . . . 3
- Rust . . . 4
- Bean Blight, Bacteriosis of Beans . . . 4

BEET:
- Leaf Spot . . . 7

CABBAGE AND CAULIFLOWER:
- Club Root . . . 7
- Bacterial Wilt of Cruciferae (Black Rot of Cabbage, Turnip, Rutabaga, etc.) . . . 9
- Bacterial Soft Rot . . . 42

CARROT:
- Bacterial Soft Rot . . . 42

CELERY:
- Late Blight or Septoria Leaf Spot . . . 11
- Early Blight or Cercospora Leaf Blight . . . 15
- Bacterial Soft Rot . . . 42

CORN:
- Smut . . . 15
- Rust . . . 16

CUCUMBER:
- Downy Mildew or Blight . . . 17
- Anthracnose . . . 17
- Bacterial Wilt of Cucurbits . . . 17

LETTUCE:
- Drop . . . 20
- Downy Mildew . . . 20
- Leaf Spot . . . 20

MELONS (See Cucumber).

ONION:
- Onion Blight or Mildew . . . 20
- Black Mould . . . 21
- Smut . . . 21

PEA:
- Blight or Leaf Spot . . . 22
- Powdery Mildew . . . 22

POTATO:
- Late Blight and Rot . . . 22
- Early Blight or Leaf Spot Disease . . . 24
- Tip Burn . . . 25
- Common Scab . . . 25
- Powdery Scab . . . 26
- Rhizoctonia, Black Scurf . . . 26
- Soft Rot and Black Leg of Potatoes . . . 27
- Fusarium Wilt and Dry Rot . . . 34
- Potato Canker or Wart Disease of Potatoes . . . 35
- Leaf Roll . . . 36
- Mosaic . . . 36
- Curly Dwarf . . . 37

SQUASH (See Cucumber).

TOMATO:
- Leaf Spot or Blight . . . 37
- Leaf Mould, Scab . . . 37
- Blossom End or Point Rot . . . 37
- Mosaic . . . 38
- Bacterial Soft Rot . . . 44

TURNIP (See Cabbage and Cauliflower).